SOLUTIONS, INC.

Final Report

Hoechst Celanese Chemical Group, Ltd.
Bay City, Texas
MIT/Fall-off Report
Injection Well WDW-49 (Well No. 4)

March 1996

ECO Solutions, Inc.
9800 Richmond Avenue
Suite 320
Houston, Texas 77042
(713) 780-1955
FAX (713) 780-0870

ECO SOLUTIONS, INC.

Hoechst Celanese Chemical Group, Ltd.
Bay City Plant
Bottom Hole Pressure Falloff and
Mechanical Integrity Testing
For WDW-49 (Well No. 4)

ECO Solutions, Inc
9800 Richmond
Suite 320
Houston, Texas 77042
(713) 780-1955

March 1996

ECO Job No. 96006

TABLE OF CONTENTS

1.0 INTRODUCTION AND EXECUTIVE SUMMARY 1

1.1 INTRODUCTION 1
1.2 EXECUTIVE SUMMARY 2
Figure No. 1 WDW-49 (Well No. 4) 4

2.0 FIELD OPERATIONS SUMMARY 5

2.1 BOTTOM HOLE PRESSURE FALLOFF SURVEY 5
2.2 MECHANICAL INTEGRITY TEST 8

3.0 MECHANICAL INTEGRITY TESTING 10

3.1 ANNULUS PRESSURE TEST 10
3.2 RADIOACTIVE TRACER SURVEY 10
3.3 ESTIMATED TIME TO RUN STATIONARY SURVEY SEQUENCE 11

4.0 BOTTOM HOLE PRESSURE FALLOFF TEST 12

4.1 BOTTOM HOLE PRESSURE FALLOFF ANALYSIS 12
4.2 COMPARISON TO PETITION MODEL DATA 12

Table 4.1 Summary of Results 14
Table 4.2 Well Information 15
Table 4.3 Calculated Results 16
Figure 2 Semi-Log (Horner) 17
Figure 3 Semi-Log (Horner Expanded View) 18
Figure 4 Semi-Log (Storage-Skin-Boundaries) 19
Figure 5 Derivative (Type Curve) 20
Table 4.4 Radial Flow Analysis (Horner Time) 21
Table 4.5 Bourdet Et Al Type Curve Analysis 24
Figure 6 Upper Miocene Injection Sand Modeled Formation Pressures 26

4.3 CALCULATION FLOW CHART AND CALCULATIONS OF PARAMETERS 27
4.4 STATIC GRADIENT SURVEY 30

APPENDICES

APPENDIX A — RADIOACTIVE TRACER LOG AND ATLAS WIRELINE'S INTERPRETATION LETTER

APPENDIX B — ANNULUS PRESSURE TEST DATA AND PLOTS

APPENDIX C — CALIBRATION CERTIFICATES

APPENDIX D — FALLOFF PLOTS

APPENDIX E — FALLOFF DATA
FLOW RATE DATA

APPENDIX F — STATIC GRADIENT SURVEY

APPENDIX G — CORRESPONDENCE

APPENDIX H — FALLOFF DATA DISKETTE

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

1.1 INTRODUCTION

Hoechst Celanese Chemical Group, Ltd. (HCCG) contracted ECO Solutions, Inc. (ECO) to perform the annual mechanical integrity testing on their Class I nonhazardous injection well, WDW-49 (Well No. 4), located at their Bay City facility. A schematic drawing of WDW-49 is included as Figure 1. The attached report details the data and test results associated with the mechanical integrity testing.

The following provides an overview of the key elements of the testing on WDW-49 (Well No. 4).

- An Annulus Pressure Test (APT) was conducted to satisfy the annual mechanical integrity test (MIT) requirements of the Texas Natural Resource Conservation Commission's (TNRCC), Underground Injection Control (UIC) Program.
- A Radioactive Tracer (RAT) survey was conducted to satisfy the annual MIT requirements of the TNRCC.
- Bottom Hole Pressure (BHP) Falloff testing was conducted to satisfy the annual ambient monitoring requirements of the U.S. Environmental Protection Agency (EPA) and the TNRCC

HCCG personnel contacted the TNRCC personnel to inform them of the MIT schedule on WDW-49 and whether a field inspector would be present. TNRCC personnel informed HCCG that no field inspector would be present for this MIT.

The APT on WDW-49 (Well No. 4) was conducted on Thursday, March 7, 1996, and was witnessed by Mr. Wesley Smith of ECO and Mr. Ray Horton of HCCG. The RAT survey was conducted on Thursday, March 7, 1996, and was witnessed by Mr. Wesley Smith of ECO.

The BHP/falloff test was conducted on Tuesday, March 12, 1996 through Thursday, March 14, 1996 and was witnessed by Mr. Wes Smith of ECO and Mr. Ray Horton of HCCG.

1.2 EXECUTIVE SUMMARY

The MIT was successfully conducted on March 7, 1996 on WDW-49, and HCCG returned WDW-49 to injection service. The BHP/Falloff test was conducted from March 12 through 14, 1996. A summary of the results of the MIT and BHP/Falloff surveys are as follows:

Radioactive Tracer Survey

The analysis of the RAT survey performed on March 7, 1996 demonstrated external mechanical integrity since no upward fluid movement from the injection interval adjacent to the long string casing is occurring. This determination can be made as a result of (1) the favorable comparison of the before and after base gamma ray surveys, (2) the two multiple pass tracer surveys and the two stationary surveys conducted 20' above the screened interval. All surveys showed no evidence of upward fluid movement. This interpretation was supported by an independent evaluation letter provided by Atlas Wireline Services (Atlas) and is included in Appendix A together with the RAT log.

Annulus Pressure Test

A demonstration of internal mechanical integrity was supported by an APT conducted on March 7, 1996. The annulus was pressurized to a maximum of 1153 pounds per square inch gauge (psig). The APT was monitored for sixty minutes. During the final 30 minutes the pressure dropped from 1150 to 1148 psig, then up to 1150 psig, or a zero pressure loss/gain pound per square inch (psi) (0%), which is well within the 5% pressure loss criteria set by the TNRCC. The APT data and plot are included in Appendix B.

Bottom Hole Pressure Falloff Survey

Waste effluent fluid was injected into WDW-49 at a steady rate of 219 gallons per minute (gpm) for 91 hours and was shut-in for a total of 39 hours. The shape of both the pressure and pressure derivative curves on log-log plots at early times are reasonable, and are similar to the survey conducted in March 1995. A full discussion of the falloff analyses is presented in Section 4.0.

Conclusions

All field work associated with the MIT/BHP/Falloff survey on HCCG's WDW-49 at the Bay City Plant conducted from March 7 through 14, 1996, was successfully completed. WDW-49 has mechanically integrity at this time and is suitable for continued use as a Class I waste injection well.

In accordance with the TNRCC/UIC Program, 31TAC, 331.4 and 331.43, the mechanical integrity test conducted on WDW-49 demonstrated that (1) 'there is no significant leak in the casing, tubing or packer" and (2) 'there is no significant fluid movement into an underground source of drinking water (USDW) through vertical channels adjacent to the injection borehole."

HOECHST CELANESE CHEMICAL GROUP, Ltd.

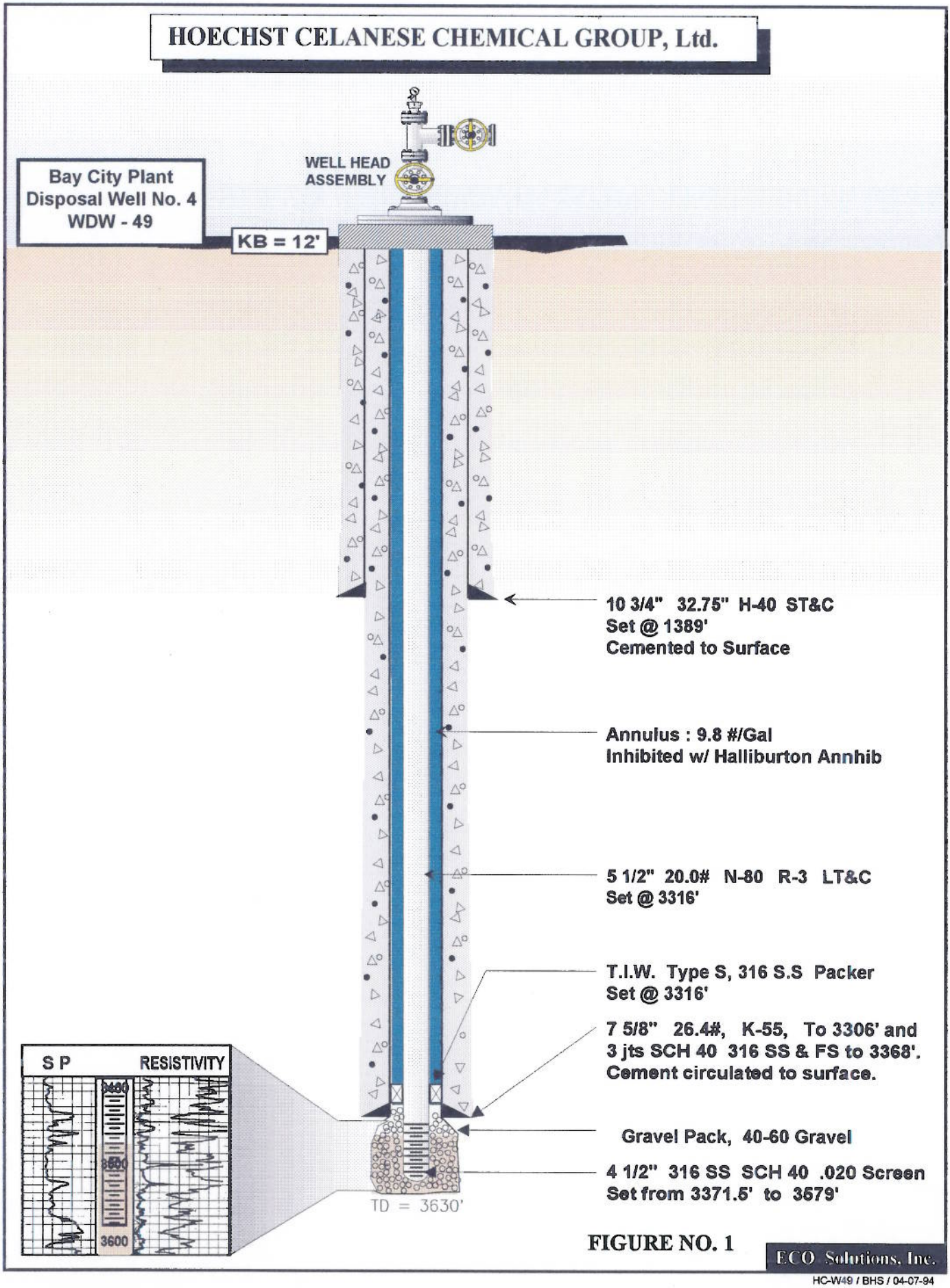


FIGURE NO. 1

ECO Solutions, Inc.

HC-W49 / BHS / 04-07-94

2.0 FIELD OPERATIONS SUMMARY

2.1 BOTTOM HOLE PRESSURE/FALLOFF SURVEY

Friday, March 1, 1996

Brought injection up from zero to 186 gallons per minute (gpm) at 1800 hours.

Saturday, March 2 - Monday, March 4, 1996

Continued injecting at an average rate of 186 gpm.

Tuesday, March 5, 1996

Wes Smith arrived at plant location at 0700 hours, checked in with front gate security guard and went to WDW-49 well site at 0730 hours. Milton Cooke Company (Cooke) personnel checked in at 0630 hours and drove to well site. Effluent was being injected at a well head pressure (WHP) = 436 pounds per square inch gauge (psig). Cooke commenced rigging up on well. NOTE: All depths are referenced to rotary drive bushing (RKB) at 12' above ground level.

WDW-49 (Well No. 4)	active/injecting
WDW-14 (Well No. 2)	out of service
WDW-32 (Well No. 3)	out of service
WDW-110 (Well No. 1-A)	out of service

Checked with Paul Richardson and Andy Bradley in the control room. WDW-49 injecting at approximately 186 gpm. At 0800 hours Cooke started pressure gauge calibrations on the following tools:

EPG 520 Serial # 69681 (Surface ReadOut) - Range 0 - 2500 psia.
EMS 725 Serial # 76651 (Back-up, Memory gauge)

Met with Ray Horton and Brian Barrington at 0845 hours to review test procedures and current condition of injection well. At 0850 hours placed tool string in lubricator (+/-18' length) as follows:

Length	Description
1.0'	Cable head
2'	Collar locator
1-1/4'	EPG 520 (SRO gauge)
4'	EPG 725 (memory gauge)
5'	weight bar
5'	weight bar

At 0851 hours opened master valve, pressured up lubricator, and prepared to go in hole. At 1055 hours check SRO gauge (WHP = 449.95 pounds per square inch absolute (psia)) and going into hole. Tied into packer (1995 RAT log) at 3316' using casing collar locator (CCL). Based on CCL recorder, correlated tool depth to packer depth tagged plugged back total depth (PBTD) at 3408; and pulled BHP tools up to 3300' at 1100 hours.

Met with shift supervisor, prepared to shut-down injection operations. Partially stopped injection pumps at 1300 hours and fully stopped injection pump at 1400 hours.

Due to the partial shut down of WDW-49, the initial falloff survey was canceled and rescheduled to commence at 1800 hours on March 8, 1996. Cooke pulled tool out of the hole and rigged down. Moved off location at 1730 hours. Well was left injecting waste effluent at a rate of 190 gpm.

Friday, March 8, 1996

Commenced injection at 219 gpm at 1800 hours.

Saturday March 9 - Monday, March 11, 1996

Continued injecting at an average rate of 219 gpm.

Tuesday, March 12, 1996

Injecting effluent into WDW-49 at the rate of 219 gpm. Wes Smith arrived at plant location at 0700 hours, checked in with front gate security guard, and drove to WDW-49. Cooke personnel checked in at 0630 hours and drove to well site. The same well conditions prevailed on all four injection wells as noted on March 5, 1996.

Checked with Paul Richardson and Andy Bradley in the control room. At 0800 hours Cooke commenced pressure gauge calibration on BHP tools (Note: EPG 520 SRO - Serial No. 80179 and EPG 725 memory tool, Serial No. 76653). At 0900 hours placed same tool string sequence as noted on March 5, 1996 in lubricator. Opened master valve, pressured up lubricator, and prepared to go into hole. Initial WHP 476.85 psia. Tied into

the packer (@3316') using CCL. Pulled tool up to 3300' at 1050 hours and commenced monitoring injection pressures and temperatures.

Monitoring injection operations at 1200 hours.

Injection rate	219 gpm
Down hole injection pressure	1891.13 psia
Surface injection pressure	467 psig

Met with shift supervisor, prepared to shut down injection operations on WDW-49. Stopped injection pumps at 1300 hours and begin falloff survey. Double block @ injection and boiler feed water flow lines.

Final injection conditions:	
Injection rate	219 gpm
Down hole injection pressure	1891.64 psia
Surface injection pressure	467 psig

Wednesday, March 13, 1996

Continue monitoring fall-off period of test (0800 hours).

Shut-in down hole pressure	1509.00 psia
Surface shut-in pressure	65.9 psig

2200 hours continue monitoring fall-off period of test.

Shut-in down hole pressure	1507.60 psia
Surface shut-in pressure	64.2 psig

Thursday, March 14, 1996

0200 hours continue monitoring fall-off period of test.

Shut-in down hole pressure	1507.31 psia
Surface shut-in pressure	63.9 psig

At 0400 hours recorded final downhole pressure, and printed final BHP plots. Pull out of hole with tool, making static gradient stops (15 minutes/stop) at 3000', 2000', 1000', 500' and surface and downloaded ASCII data file.

Final shut-in pressures/temperature

Shut-in down hole pressure	1507.23 psia
Shut-in down hole temperature	102.17 Deg. F
Surface shut-in pressure	63.6 psig

At 0530 hours gauges in lubricator and end of pressure falloff survey. Begin rigging down wireline equipment. Cooke crew left location at 0830 hours.

Moved in and rigged up B&G Wireline Service bobtail pump truck. First, picked up a 50-barrel load of 10 pound per gallon brine from a frac tank located at WDW-14. Transported the brine to WDW-49, rigged up and pumped the brine down the tubing at a rte of 1 to 1.5 barrels per minute and a surface pressure of 450 psig to zero. Brining operations on WDW-49 completed at 1700 hours. Rigged down B&G Wireline and moved off location. Wes Smith returned to Houston. All field work on WDW-49 associated with the MIT/BHP/falloff survey and brining-in is complete.

2.2 MECHANICAL INTEGRITY TEST

Thursday, March 7, 1996

At 0730 hours Mr. Wes Smith of ECO and Mr. Ray Horton of HCCG traveled to WDW-49 and met with Mr. Wilson Cupples with HCCG's instrument group to conduct and witness the APT. WDW-49 was shut-in with 63 psig on the tubing gauge and 256 psig on the annulus. HCCG's facility pressure recorder was used. Also, a certified calibrated pressure gauge, CMM Pressure Sensor, Serial No. 97223 with a range from zero to 2,000 psig, was installed onto the annulus outlet. WDW-49 had been shut-in for continuous period of 44 hours. HCCG personnel pressurized the annulus system using nitrogen. The annulus was tested to a maximum pressure of 1153 psig. The annulus was monitored for 60 minutes revealing a maximum pressure change from 1152 to 1148 psig. However, during the final 30 minute period, a zero pressure loss on the annulus was measured at 1150 psig, or 0 psi change (0%). After completion of the APT, the nitrogen gas was bled off the annulus lowering the pressure to 250 psig. WDW-49 was left shut-in.

At 0830 hours Atlas Wireline Service (Atlas) personnel arrived at HCCG's Bay City plant, checked through plant security and went through safety orientation. Moved in and rigged up Atlas' wireline unit including radioactive (RA) tools on WDW-49. At 1300 hours

started the RAT survey as witnessed by Mr. Wes Smith of ECO. Ran tool into hole and tagged bottom of borehole at a maximum depth of 3520'. Ran base gamma ray (GR) log, a short repeat section and one statistical check. Commenced injecting waste effluent into well at 1330 hours. Ran multiple pass survey from 3420' to 3000' at an injection rate of 50 gpm, depicting all injected fluid was entering the injection interval below the bottom of the borehole. Repeated multiple pass survey and obtained similar positive results. Set the RAT tool at 3350' for a stationary survey, injected a RA slug at the same injection rate and monitored for 20 minutes with no indicated upward flow. Repeated stationary survey with same positive results. Ran the final baseline GR log from 3420' to 3000'. Completed the RAT survey at 1900 hours and pulled the tool out of the hole. Rigged down Atlas and moved off site. WDW-49 was left operating at an injection rate of 190 gpm.

3.0 MECHANICAL INTEGRITY TESTING

3.1 ANNULUS PRESSURE TEST

An APT was conducted on Thursday, March 7, 1996 to demonstrate internal mechanical integrity. The APT was witnessed by Mr. Ray Horton of HCCG and Mr. Wesley Smith of ECO. The annulus was pressurized to a maximum pressure of 1153 psig with 66 psig on the tubing. The APT was monitored for plus sixty (60) minutes using a certified calibrated pressure gauge and facility recorder. During the final 30 minutes the pressure was measured from 1150 to 1148 psig and back up to 1150 psig for zero pressure change, or 0 psi (0%), which was well within the 5% pressure loss criteria set by the TNRCC. APT data and plot are included in Appendix B.

3.2 RADIOACTIVE TRACER SURVEY

On Thursday, March 7, 1996 a RAT survey was conducted by Atlas to demonstrate external mechanical integrity and to insure that all fluids are entering the injection interval. The RAT was witnessed by Mr. Wes Smith of ECO. Analysis of the RAT survey showed no upward fluid movement. Atlas and ECO conducted the RAT as follows:

1. Ran API gamma-ray (GR) tie-in strip.
2. Ran initial baseline GR log from 3420' to 3000'.
3. Ran repeat GR log from 3400' to 3220' to confirm tool repeatability.
4. Ran 5-minute statistical check at 3350'.
5. Made multiple pass survey #1 with RA slug ejected at 3000' and a pump rate of 50 gpm.
6. Made multiple pass survey #2 with a RA slug ejected at 3000' and a pump rate of 50 gpm.
7. Ran stationary survey #1 at 3350'. Watched RA slug pass tool and monitored for 20 minutes. Pump rate 50 gpm.
8. Ran stationary survey #2 at 3350'. Watched RA slug pass tool and monitored for 20 minutes. Pump rate 50 gpm.
9. Ran after survey base GR log from 3420' to 3000'. RAT survey completed.

3.3 ESTIMATED TIME TO RUN STATIONARY SURVEY SEQUENCE

The purpose of this estimate is to calculate the "worst case" time for the radioactive slug to move from the GR tool (1) down the tubing, (2) into the perforations, and (3) up the casing/borehole annulus to the tool depth.

Basic Data:

Capacities:	4-1/2" liner	-	0.653 gal/ft.
	4-1/2" liner x 9-7/8" borehole	-	3.15gal/ft.
Pump Rate:	50 gpm		

Note: RAT detection tool was held stationary at 3350 feet, or 25 feet above the top of the screened section (receiving fluid) at +/-3375'.

Worst Case Calculations:

Volumes:	Liner	- 25 ft. x 0.653 gal/ft.	=	16.3
	Liner/borehole	- 25 ft. x 3.15 gal/ft.	=	78.8
		TOTAL		95.1 gallons

Calculated time to circulate RA slug around the end of the tubing and casing strings:

= 95.1 gal / 50 gpm

= 1.9 minutes

Note: Actual time surveys were run = 20 minutes

4.0 BOTTOM HOLE PRESSURE FALLOFF

4.1 BOTTOM HOLE PRESSURE FALL-OFF ANALYSIS

Purpose Of Test: Required annual Reservoir Evaluation Test for year **1996.** Calculate the following reservoir characteristics: permeability, skin damage, pressure drop due to skin and flow efficiency.

Analysis Description - Fall-Off Test

Method Of Interpretation: The following analysis was performed by utilizing both Semi-Log and Log-Log analysis. The Semi-Log curve was generated by plotting the Pressure vs the Superposition time function, utilizing the given rate history. The semi-log straight line was calculated by linear regression through the infinite acting flow period of the curve. The slope **m**, $\mathbf{P_{1hr}}$ values were obtained from this curve and utilized for permeability and skin calculations. The Log-Log curves were generated by plotting ΔP and Pressure derivative vs the Agarwal Equivalent time function, $[t_p\ \Delta t/(t_p+\Delta t)]$. The Log-Log curves were simultaneously positioned over Bourdet et al type curves until a solution match was obtained. Permeability and skin values were calculated from this match and then compared with those obtained from the Semi-Log analysis.

A. Semi-Log (Horner): The straight line area of the semi-log curve was identified by first using the 1-1/2 log cycle rule to estimate the end of wellbore storage effects. Secondly, the time of the flat portion from the Pressure Derivative curve was used in determining the area of the semi-log curve in which the straight line was drawn. The semi-log yielded a slope value of **7.0 psi/cycle** and a P_{1hr} of **1522 psi**. The pressure difference between P_{1hr} and the injection pressure, P_{inj} of **1892 psi** compared with the calculated slope would give indications of positive skin damage and high permeability.

B. Log-Log (Bourdet et al Type Curves): Development of the unit slope line in the early portion of the derivative curve coupled with the high maximum of the derivative is indicative of a damaged well with wellbore storage. The flattening portion of the derivative curve at 0.5 P_d/P_d' indicates the beginning of the radial flow regime and was observed approximately five hours into the fall-off test. The flat portion of the derivative curve was the main factor used to obtain a type curve match yielding similar results to the semi-log analysis.

4.2 COMPARISON TO PETITION MODEL DATA

The reservoir properties (pressure, permeability, etc.) of the upper Miocene injection interval were determined through fall-off testing conducted on WDW-49. The following or operational formation pressures from the tests can be compared with the modeled

EPA - PAN 4/25/96 SMC

m = 6.874
K = 1463
h = 85
s = 55
ΔP = 329

1892 - 329 = 1562

operational pressures by converting the measu
ground level and removing the pressure increa
0.435 psi/ft was used to correct all pressures
The formation pressures predicted by the mod
other near-wellbore conditions. The measured
and maximum predicted operational pressures a

Formation I

WDW-49 (Well 4) Depth	Flowing Formation Pressures, psia	Skin Pr... Loss, psi	Formation Pressure, psia	Modeled Pressure, psi
3300'	1892	329	1563	NA
3440'	1953	329	1624	1639

The measured flowing pressure is below the maximum modeled operational pressure by 15 psi for WDW-49. A graph of the modeled pressures for WDW-49 is included. The graph shows the yearly predicted modeled injection rates (250 gpm for each well). All predicted operational pressures correspond to a depth of 3440' below ground level and an original estimated formation pressure for the upper Miocene injection interval of 1555 psi.

The measured static formation pressures from the well tests, corrected to a depth of 3440' below ground level, show a formation pressure increase of 13 psi. This illustrates that injection operations at the plant have had limited impact on formation pressures.

Static Formation Pressures From WDW-49 Well Test

Original Estimated Formation Pressure at 3440'	Static Formation Pressure at 3440'	Formation Pressure Increase, psi
1555	1568	+13

A comparison of the test permeability and transmissivity values with the modeled values of permeability and transmissivity for WDW-49 are given below:

Well Name	Test Permeability, md	Petition Permeability, md	Test Transmissivity, md-ft/cp	Petition Transmissivity, md-ft/cp
WDW-49 (well 4)	1448	1350	173,315	313,700

Conclusions: This particular well was diagnosed to be injecting into a homogeneous reservoir with a calculated permeability of **1445 (md)** and skin damage of **+30** utilizing an h_{net} value of **85 feet**. The flow efficiency of **14.4%** suggests that the near wellbore conditions impact the injection volume limitations. Also, the total pressure drop is primarily due to conditions within a small radius from the well.

The following Table is provided to give comparative results with the previous tests and calculations. The primary variables affecting the calculated results are included.

Table 4.1
SUMMARY OF RESULTS

Date MM/YY	Rate gpm	h_{net} ft	μ_w cp	slope psi/cycle	kh/μ	kh md-ft	k md	Skin
3/96	**219**	**85**	**0.7100**	**7.0**	**173,315**	**123,054**	**1448**	**+53**
03/95	**279**	**85**	**0.7100**	**8.486**	**183,299**	**130,142**	**1531**	**+49**
03/94	168	85	0.7100	5.517	169,620	120,430	1417	+70
09/92	79.5	85	0.7000	2.710	163,584	116,145	1366	+117

The calculated results indicate a difference in transmissivity, (kh/μ) of **5.4%** coupled with a **8.2%** difference in skin values between 1995 and 1996. In addition, the results calculated from type curve analysis compare favorably to those calculated from the semi-log straight line analysis thus supporting the integrity of the calculated results.

Note: The start time of the infinite acting flow period exceeded the time to exit the waste front, therefore the viscosity of the original reservoir fluid was used for the final analysis.

Table 4.2

WELL INFORMATION

Well Type: Injection
Screen: 3371.5' - 3579' (Gravel Pack Screen)

Test Gauge Depth: 3300 feet
Extrapolated Depth: 3440 feet

[Input Parameters]

Reservoir Pressure	psia	P	1507
Reservoir Temperature	Deg.F	T	102
Final Static Pressure	psia	P_{si}	1568
Final Injection Pressure	psia	P_{inj}	1953
Water Flow Rate	gsl/min	q_w	219
Sand Thickness	feet	h_{net}	85
Wellbore Radius	feet	r_w	0.4580
Formation Porosity	%	ϕ	33.0
Extrapolated Pressure	psia	P*	1504
Extrapolated Pressure @ 1 hr	psia	P_{ihr}	1522
Semi=Log Slope	psi/cycle	M	7.053
Injection Time	hrs	t_p	91.0
Shut-in Time	hrs	t_{si}	39.0

[Fluid Properties]

Fluid Viscosity	cp	μ_w	7.1000E-01
Formation Volume Factor	RB/STB	β_w	1.0000E+00
Fluid Compressibility	1/psi	C_w	3.0547E-06
Total Compressibility	1/psi	Ct	5.0000E-06

Table 4.3
Calculated Results

[Semi-Log Analysis - Multi-Rate Method]

Transmissibility	md-ft/cp	kh/u	173,315
Flow Capacity	md-ft	kh	123,054
Permeability	md	k	1448
Skin Damage	total	S	+53
Pressure Drop Due to Skin	psi	dP	+328.7
Flow Efficiency	%	FE	+14.4
Radius of Investigation	feet	r_i	8906

[Type Curve (Log-Log) Analysis]

Transmissibility	md-ft/cp	kh/u	173,071.26
Flow Capacity	md-ft	kh	122,880
Permeability	md	k	1445
Skin Damage	total	S	+30.1
Pressure Drop Due to Skin	psi	dP	184.5
Flow Efficiency	%	FE	+52

FIGURE 2

HORNER
PRESSURE BUILDUP PLOT

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14, 1996

$[k_1/u]_t$=2039.00 k_1=1447.69 md s=53.7 p*=1504.4

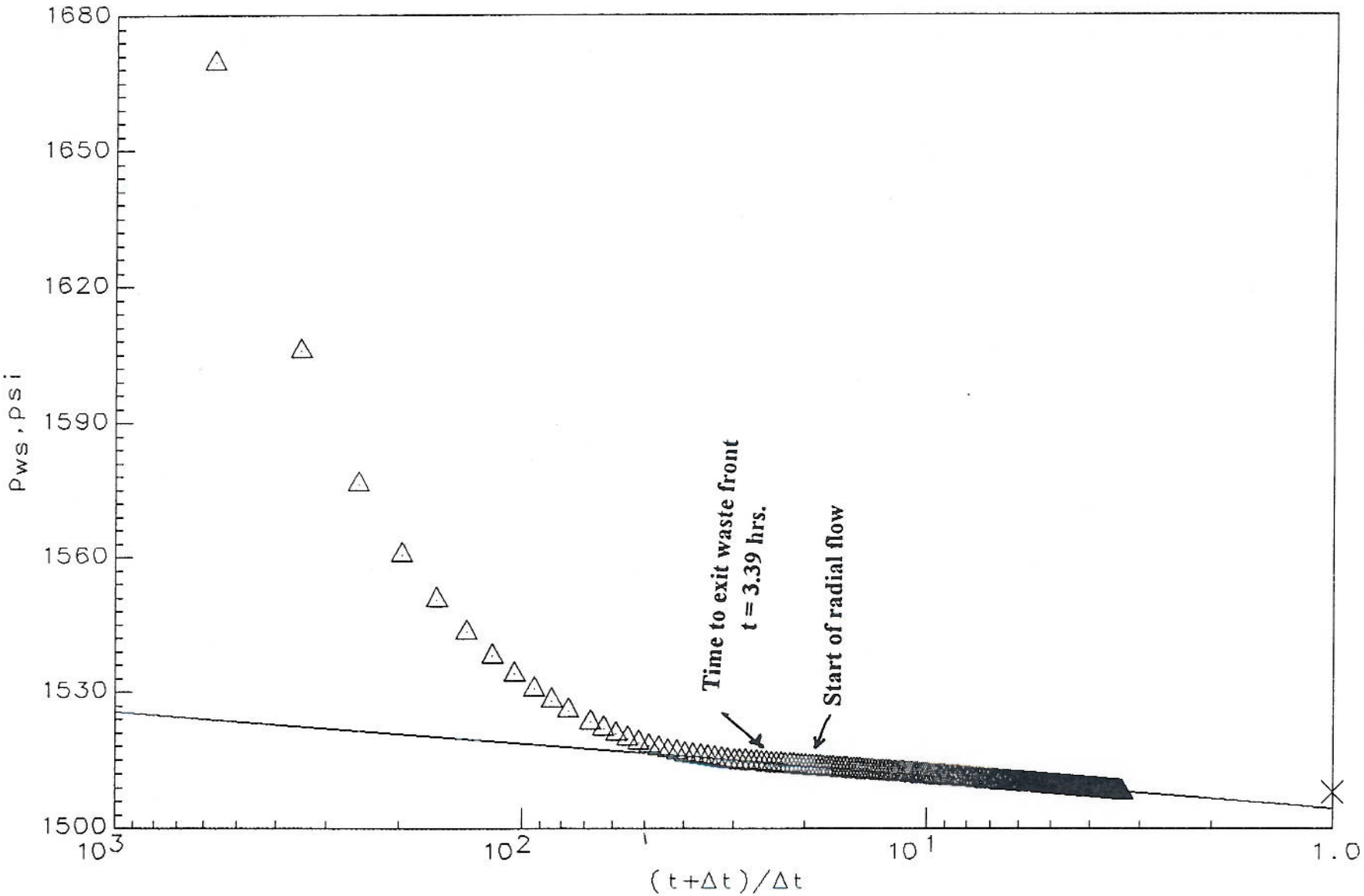


FIGURE 3

HORNER
PRESSURE BUILDUP PLOT

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14, 1996

$[k_1/u]_t$=2039.00 k_1=1447.69 md s=53.7 p*=1504.4

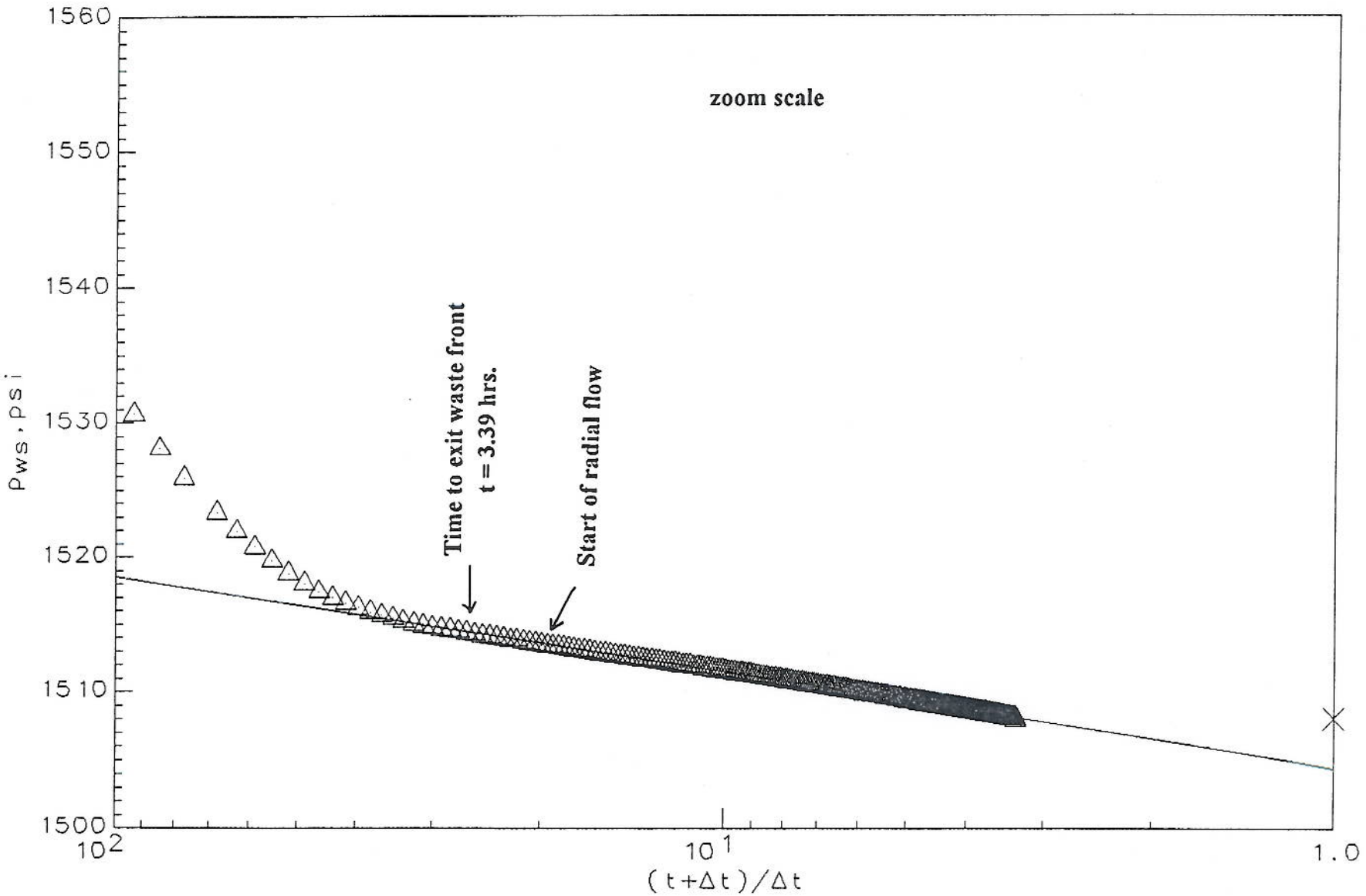


FIGURE 4

STORAGE AND SKIN TYPECURVE (Bourdet et al)

PRESSURE FALLOFF PLOT

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14, 1996

$[k_1/u]_t$=2036.13 k_1=1445.65 C_D=6778 s=30.1

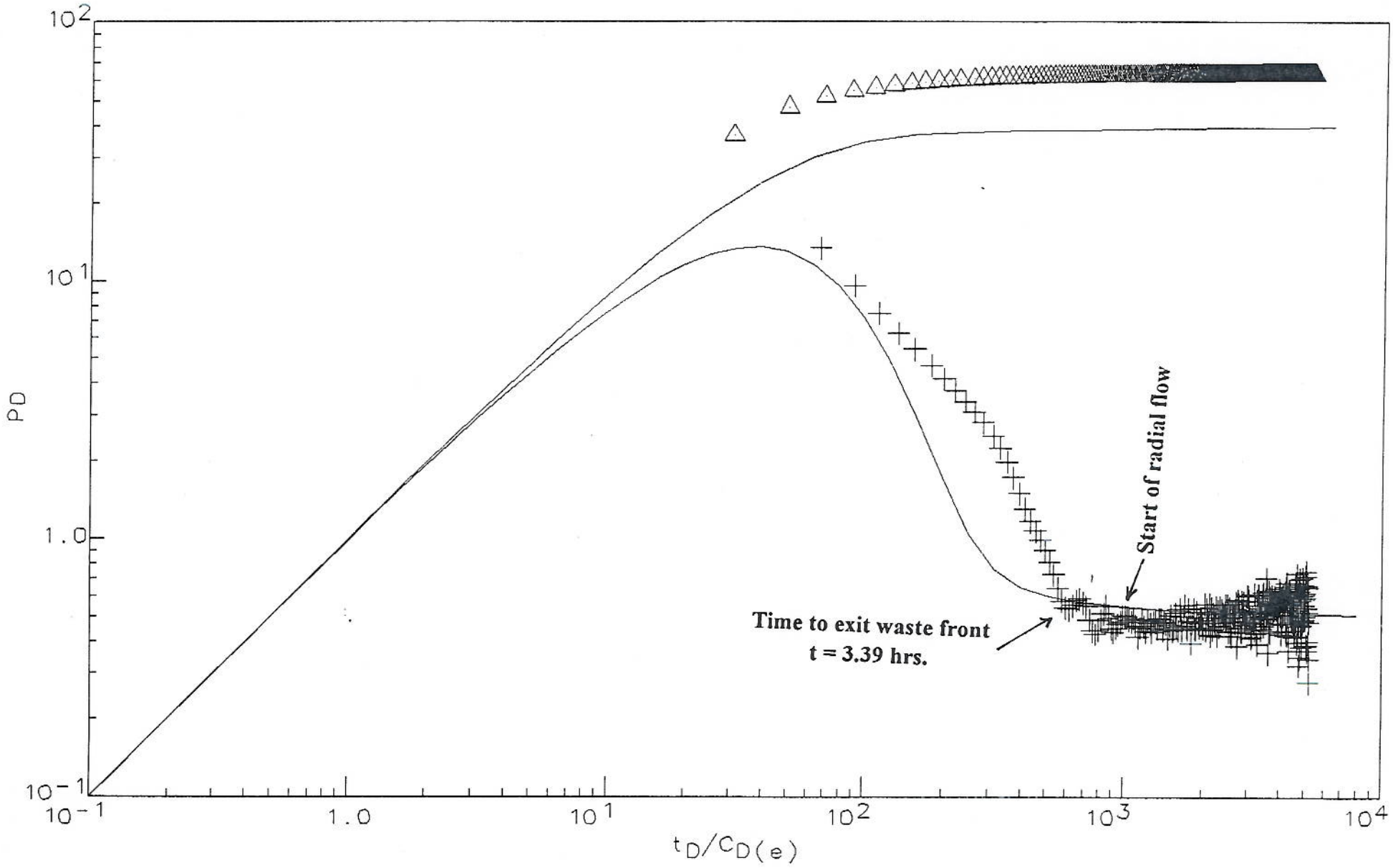


FIGURE 5

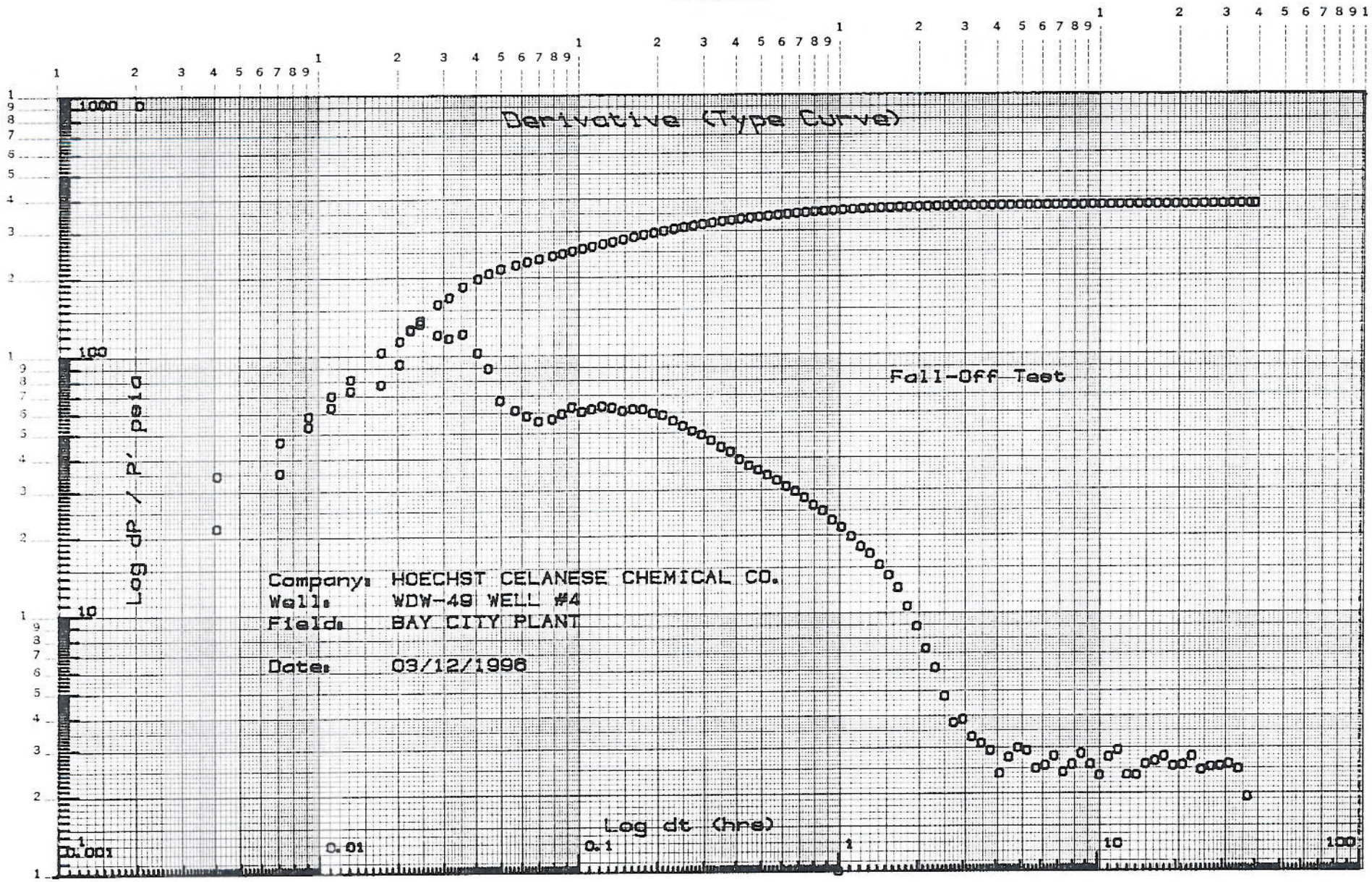


TABLE 4.4

Water Well Test - BUILDUP

Radial Flow Analysis

(Horner Time)

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14,1996

Zone 1

Extended Rates

3 - Month Constant Rate	=	-	bbl/d	
6 - Month Constant Rate	=	-	bbl/d	

Stabilized Rate

Shape Code	=	R1A		<DEF>
Drainage Area	A =	160.0	acres	<DEF>
Time To Stabilize	ts =	2.550	hr	
Stabilized Rate @ Current Skin	qs =	-10162.31	bbl/d	
Stabilized Rate @ Skin Of 0	qs =	-78719.76	bbl/d	
Stabilized Rate @ Skin Of -4	qs =	-158138.28	bbl/d	

Water Well Test - BUILDUP

Radial Flow Analysis

(Horner Time)

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14,1996

Zone 1

Pressures

Initial Pressure	pi	=	1508.0	psi
Extrapolated Pressure	p*	=	1504.4	psi
Average Reservoir Pressure	pR	=	-	psi
Final Flowing Pressure	pwfo	=	1892.5	psi

Straight Line Results

Total Sandface Rate	QTBT	=	-7508.00	bbl/d
Semilog Slope	msl	=	7.0	psi/cycle
Transmissivity (Total)	kh/mu	=	173315.17	md.ft/cp
Mobility (Total)	k/mu	=	2039.002	md/cp
Flow Capacity (Water)	kh	=	123053.77	md.ft
Permeability (Water)	k	=	1447.69	md
Skin Effect (Total)	s	=	53.733	
Pressure Drop Due To Skin	delps	=	328.7	psi
Flow Efficiency	FE	=	1.64	
Damage Ratio	DR	=	0.61	
Radius Of Investigation	r(inv)	=	-	ft
@ Time Of Investigation	t(inv)	=	-	hr

Water Well Test - BUILDUP

Radial Flow Analysis

(Horner Time)

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14,1996

Reservoir Parameters

Net Pay	h =	85.00 ft	
Total Porosity	phit =	33.00 %	
Water Saturation	Sw =	100.00 %	
Oil Saturation	So =	0.00 %	
Gas Saturation	Sg =	0.00 %	
Wellbore Radius	rw =	0.46 ft	
Formation Temperature	T =	96.00 deg F	
Formation Compressibility	cf =	2.962×10^{-06} psi^{-1}	<DEF>
Total Compressibility	ct =	5.962×10^{-06} psi^{-1}	<DEF>

TABLE 4.5

Water Well Test - FALLOFF

Bourdet Et Al Type Curve Analysis

(Equivalent Time)

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14,1996

Inner Zone

Match Curve	CDe2s	=	1.00×10^{30}	
Match Point (pressure Ratio)		=	6.1	psi
Match Point (time Ratio)		=	0.005	hr
Dimensionless Storage Constant	CD	=	6778.19	
Wellbore Storage Constant	C	=	0.26	bbl/psi
Transmissivity (Total)	kh/mu	=	173071.26	md.ft/cp
Mobility (Total)	k/mu	=	2036.132	md/cp
Flow Capacity	kh	=	122880.59	md.ft
Permeability	k	=	1445.65	md
Skin Effect (Total)	s	=	30.128	
Pressure Drop Due To Skin	delps	=	184.5	psi
Radius Of Investigation	r(inv)	=	-	ft
@ Time Of Investigation	t(inv)	=	-	hr
Number Of Points In Derivative		=	7	

Dual Porosity

Inter Porosity Coeff	Lambda	=	-	
Storativity Ratio	Omega	=	-	

Water Well Test - FALLOFF

Bourdet Et Al Type Curve Analysis

(Equivalent Time)

HOECHST CELANESE WDW-49
WELL #4

PRESSURE FALL-OFF TEST
MARCH 12-14,1996

Inner Zone

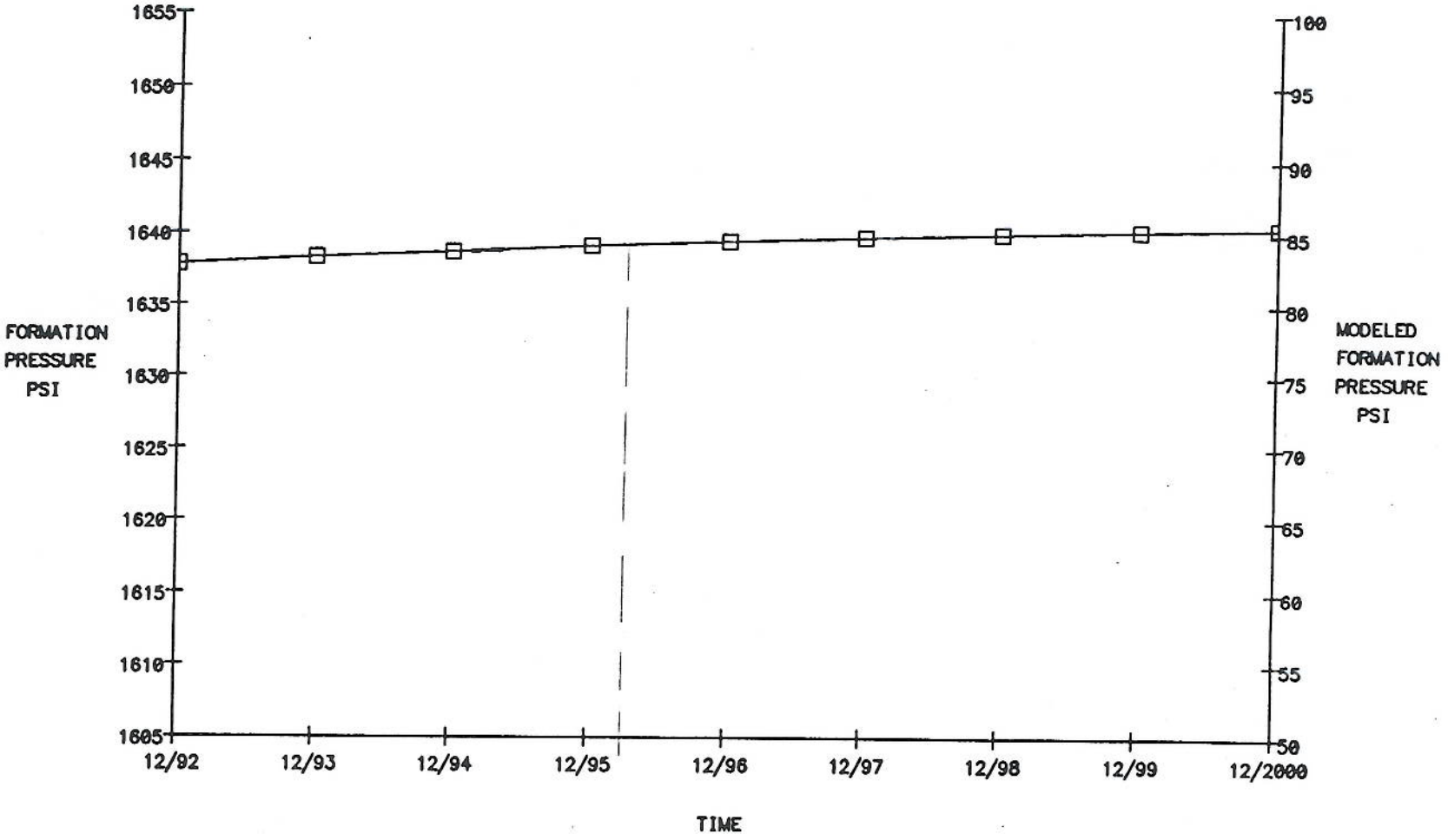
Match Curve	CDe2s	=	-	
Match Point (pressure Ratio)		=	6.1	psi
Match Point (time Ratio)		=	0.005	hr
Dimensionless Storage Constant	CD	=	6778.19	
Wellbore Storage Constant	C	=	0.26	bbl/psi
Transmissivity (Total)	kh/mu	=	173071.26	md.ft/cp
Mobility (Total)	k/mu	=	2036.132	md/cp
Flow Capacity	kh	=	122880.59	md.ft
Permeability	k	=	1445.65	md
Skin Effect (Total)	s	=	-	
Pressure Drop Due To Skin	delps	=	-	psi
Radius Of Investigation	r(inv)	=	-	ft
@ Time Of Investigation	t(inv)	=	-	hr
Number Of Points In Derivative		=	7	

Dual Porosity

Inter Porosity Coeff	Lambda	=	-	
Storativity Ratio	Omega	=	-	

FIGURE 6

UPPER MIOCENE INJECTION SAND - WDW-49



MODELED OPERATIONAL FORMATION PRESSURES IN WDW-49 (1992 - 2000)

SECTION 4.3

CALCULATION FLOW CHART

1. Calculate slope value from Semi-Log Plot.

2 a. Utilize reservoir viscosity for *Initial Calculations*.

b. If required, redo calculations with waste viscosity.

3. Calculate Permeability.

4. Calculate Time to exit waste front.

5. Conditional statements.

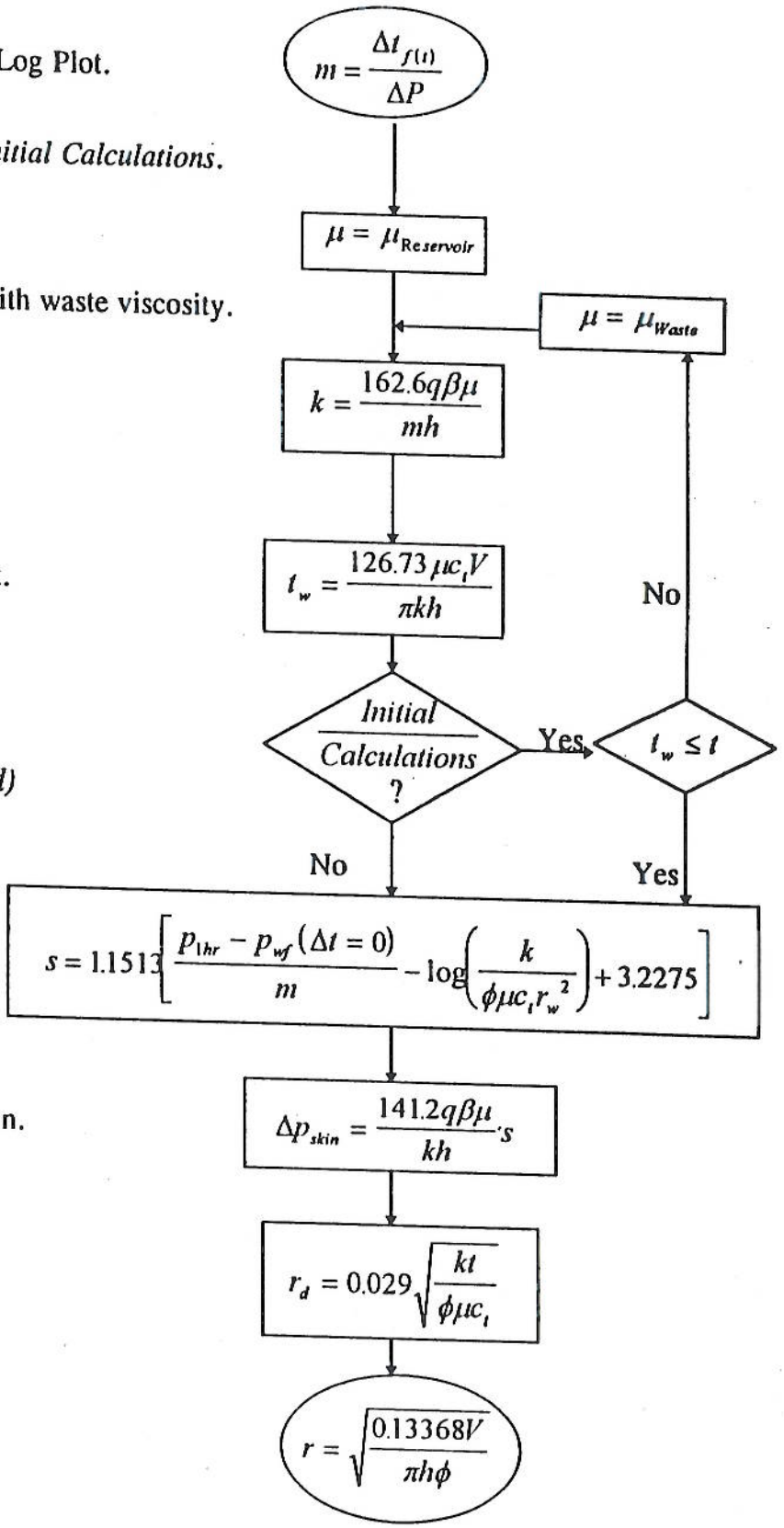
(t, beginning of radial flow period)

6. Calculate skin factor.

7. Calculate Pressure drop due to skin.

8. Calculate radius of investigation.

9. Calculate distance to waste front.



FALLOFF TEST - EQUATIONS AND CALCULATIONS

Input Parameters

Symbol	Name	Unit	Value
k	Permeability	millidarcies	1,457
q_{gpm}	Flow rate	gallons per minute	219
q_{bpd}	Flow rate	barrels per day	7,509
β	Formation volume factor	RB/STB	1.00
μ	Fluid viscosity	centipoise	0.71
m	Semi-log slope,	psi per cycle	7.0
h	Net sand thickness	feet	85
Ct	Total compressibility	1/psi	.0000050
π	Pi		3.1416
s	Skin Factor	total	53
ϕ	Porosity	fraction	.33
V	Total injected volume	gallons	1951004846
t	Time to radial flow period	hours	4.8

Calculate Permeability

Equation: $$k = \frac{162.6 q_{bpd} \mu \beta}{mh}$$

$$k = \frac{(162.6)\,(7{,}509)\,(1)\,(0.71)}{(7)\,(85)}$$

$$k = \frac{866{,}884.01}{595}$$

$$k = 1457 \text{ md}$$

Calculate Time To Exit Waste Front

Equation: $$T_w = \frac{126.73 \mu C_t V}{\pi k h}$$

$$T_w = \frac{(126.73)\,(0.71)\,(0.000005)\,(1{,}951{,}004{,}846)}{(3.1416)\,(1{,}457)\,(85)}$$

$$T_w = \frac{877740.50}{389071.45}$$

$$T_w = 2.26 \text{ hrs.}$$

Calculate Pressure Drop Due To Skin

Equation: $\Delta P_{skin} = \frac{141.2 q_{bpd} \mu \beta}{kh} s$

$\Delta P_{skin} = \frac{(141.2)\ (7{,}509)\ (1)\ (0.71)}{(1{,}457)\ (85)}$ x (53)

$\Delta P_{skin} = \frac{(39{,}897{,}990)}{(123{,}845)}$

$\Delta P_{skin} =$ 322.16 psi

Calculate Radius Of Investigation

Equation: $R_i = 0.029\sqrt{\frac{kt}{\phi \mu C_t}}$

Ri = $0.029\ [(1{,}457)\ (4.8)/\ (0.33)\ (0.71)\ (0.000005)]^{½}$

$R_i = 0.029\ [6{,}994/0.0000012]^{½}$

$R_i = 0.029\ (5{,}828{,}333{,}333.3333)^{½}$

$R_i = 0.029\ (76{,}344)$

$R_i =$ 2,214'

Calculate Distance To Waste Front

Equation: $R_{wf} = \sqrt{\frac{0.13368V}{\pi h \phi}}$

$R_{wf} = [(0.13368)(1{,}951{,}004{,}846)/(3.14)(85)(0.33)]^{½}$

$R_{wf} = [260{,}810{,}328/88.1]^{½}$

$R_{wf} = [2{,}960{,}389.65]^{½}$

$R_{wf} =$ 1,721'

4.4 STATIC GRADIENT SURVEY

A static gradient survey was conducted while pulling out of the hole immediately following the bottom hole pressure falloff test. Stops were made at 3000', 2000', 1000', 500' and surface. Data collected during the static gradient survey is included in Appendix G and presented graphically in Figure 7. Data collected at each stop were as follows:

Table 4.4
Static Gradient Survey Results

Depth (ft)	Pressure (psia)	PSI/ft
0	69.99	
500	293.30	0.447
1000	509.98	0.433
2000	943.62	0.434
3000	1376.83	0.433
3300	1507.23	0.435
3440*	1568.08	0.435

* Pressure extrapolated to mid-point screen.

ECO Solutions, Inc.
Hoechst Celanese Chemical Group, Ltd.
MIT - WDW-49 (Well No. 4)

APPENDIX A

RADIOACTIVE TRACER LOG AND ATLAS WIRELINE'S INTERPRETATION LETTER

Western Atlas International
WIRELINE SERVICES

PRODUCTION LOGGING SERVICES

FILE NO.

API NO.

FINAL PRINT

COMPANY HOECHST CELANESE CHEMICAL GROUP, LTD.
WELL WDW 49
FIELD BAY CITY PLANT
COUNTY MATAGORDA STATE TEXAS

LOCATION:
BAY CITY PLANT
SEC TWP RGE

OTHER SERVICES
NONE

PERMANENT DATUM GL ELEV. N/A
LOGGING MEASURED FROM RKB 12 FT. ABOVE P.D.
DRILLING MEASURED FROM RKB

ELEVATIONS
KB N/A
DF N/A
GL N/A

DATE	3/7/96	
RUN	1	
SERVICE ORDER	134699	
DEPTH-DRILLER	3433	
DEPTH-LOGGER	3420	
BOTTOM LOGGED INTERVAL	3419	
TOP LOGGED INTERVAL	2800	
TYPE FLUID IN HOLE		
SALINITY PPM CL.	N/A	
DENSITY LB/GAL.		
LEVEL	FULL	
MAX. REC. TEMP. DEG. F	N/A	
OPR. RIG TIME	MAST	
EQUIP. NO. / LOC.	41111 VICTORIA	
RECORDED BY	JOHNSTON	
WITNESSED BY	MR. W. SMITH	

BOREHOLE RECORD

NO.	BIT	FROM	TO

FOLD HERE

IN MAKING INTERPRETATIONS OF LOGS OUR EMPLOYEES WILL GIVE CUSTOMER THE BENEFIT OF THEIR BEST JUDGEMENT, BUT SINCE ALL INTERPRETATIONS ARE OPINIONS BASED ON INFERENCES FROM ELECTRICAL OR OTHER MEASUREMENTS, WE CANNOT, AND WE DO NOT GUARANTEE THE ACCURACY OR CORRECTNESS OF ANY INTERPRETATION. WE SHALL NOT BE LIABLE OR RESPONSIBLE FOR ANY LOSS, COST, DAMAGES, OR EXPENSES WHATSOEVER INCURRED OR SUSTAINED BY THE CUSTOMER RESULTING FROM ANY INTERPRETATION MADE BY ANY OF OUR EMPLOYEES.

R.A.T. (Mech. Integrity Test)

CASING RECORD

SIZE	WGT	FROM	TO
5 1/2	20	0	3316
7 5/8	26.4	0	3579

REMARKS RUN (1)

LOG RUN IN ORDER TO STABLISH MECH. INTEGRITY. LOG FILES ARE PRESENTED FROM TOP DOWN, IN ORDER RUN. NO INDICATION OF FLUID MOVEMENT UPWARD WAS SEEN.

LOGS BELOW CORRELATED TO PACKER
DEPTH OF 3316 FT.

LOGS BELOW CORRELATED TO PACKER
DEPTH OF 3316 FT.

FIRST BASE PASS & REPEAT BELOW
TIME IS 1230 PM, NO INJECTION
****

****

FILE: 2

CURVE DELAY REPORT

CURVE	PHYS. DELAY	UNITS
TDET	6,0	FT,IN
BDET	0	FT,IN
CCL	9,9	FT,IN

PARAMETERS

*** NONE ***

DISPLAY SCALE CHANGES

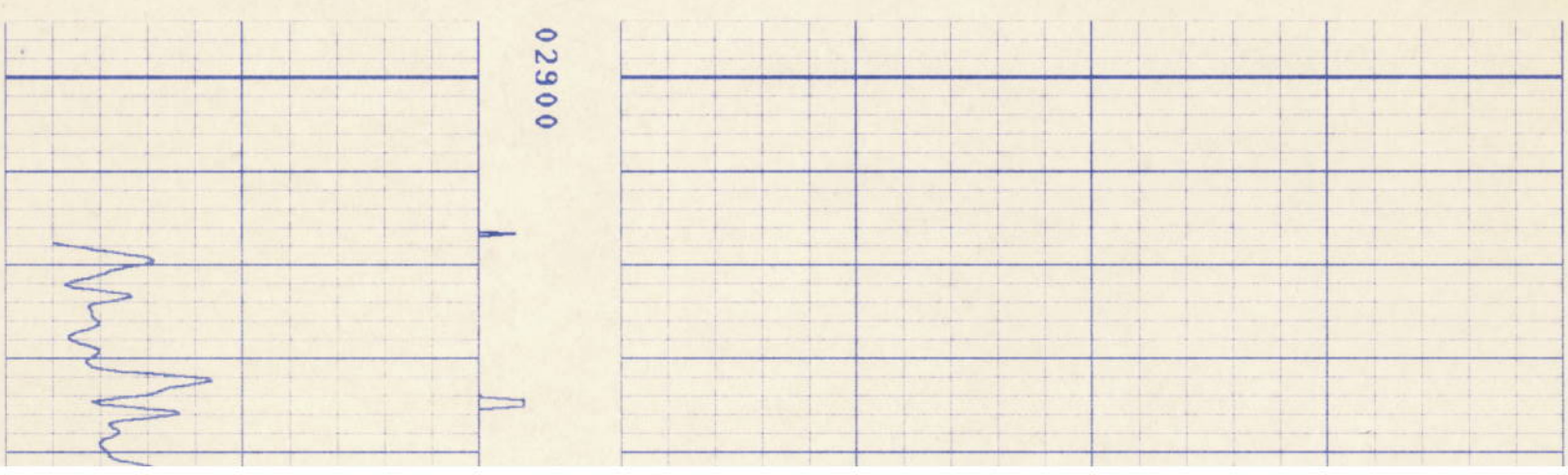
*** NONE ***

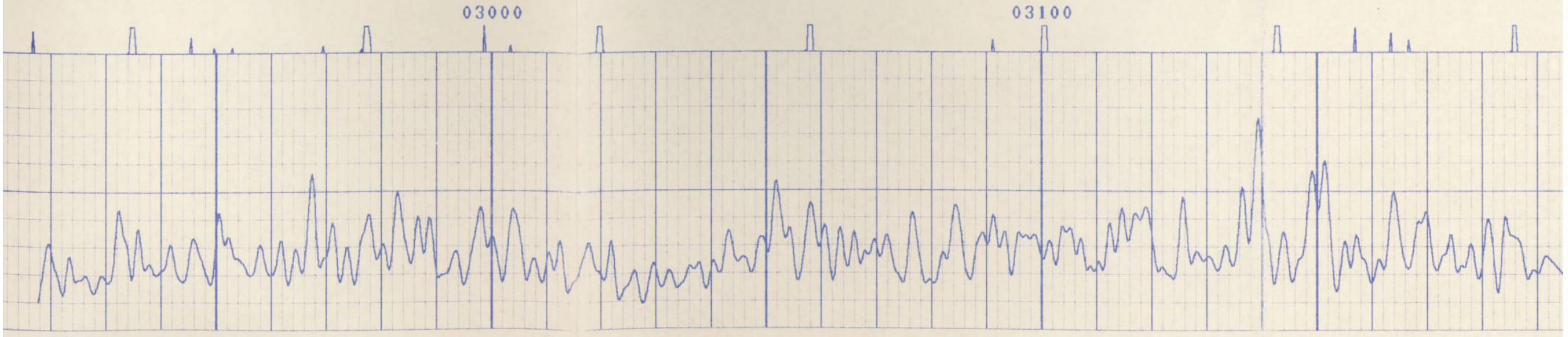
COMPANY: HOECHST CELANESE
WELL NAME: WDW 49
SERVICE: M 150A FILE: 2
REVISION: FSYS256 REV:G002 VER:2.0

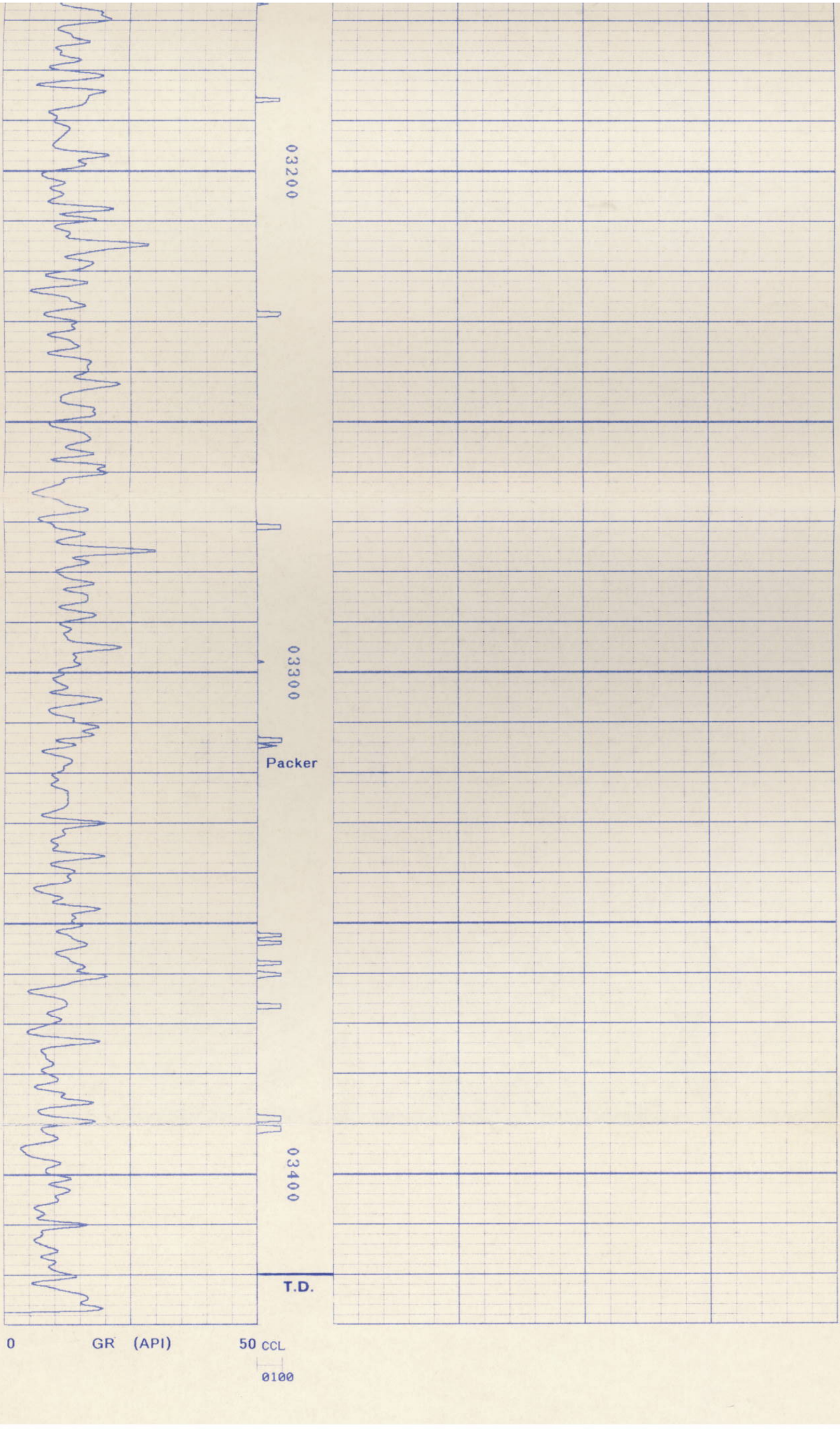
RUN: 1
TRIP: 1
DATE: 03/08/96
TIME: 12:18:41
MODE: RECORD

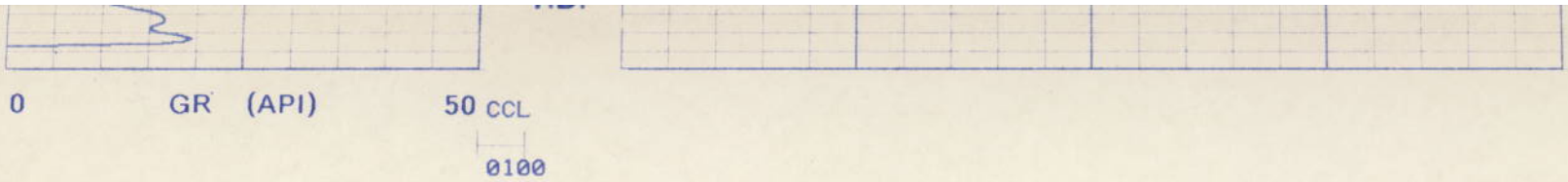
CCL
0100

0 GR (API) 50




03000
03100


03200
03300
Packer
03400
T.D.
0
GR (API)
50
CCL
0100



FILE: 2

****

****

FILE: 1

CURVE DELAY REPORT

CURVE	PHYS. DELAY	UNITS
TDET	6,0	FT,IN
BDET	0	FT,IN
CCL	9,9	FT,IN

PARAMETERS

*** NONE ***

REPEAT SECTION

DISPLAY SCALE CHANGES

*** NONE ***

COMPANY: HOECHST CELANESE

WELL NAME: WDW 49

SERVICE: M 150A FILE: 1

REVISION: FSYS256 REV:G002 VER:2.0

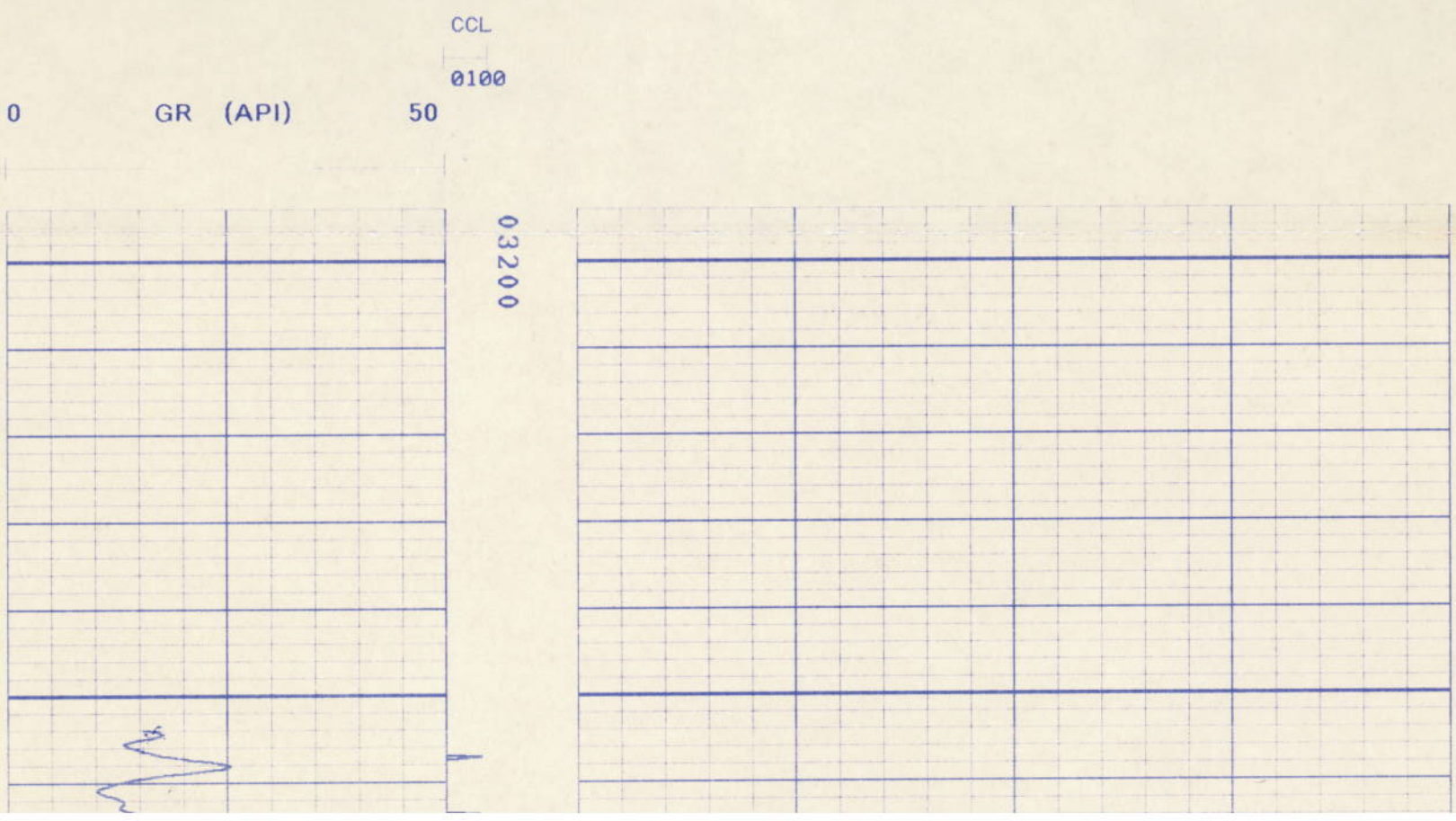
RUN: 1

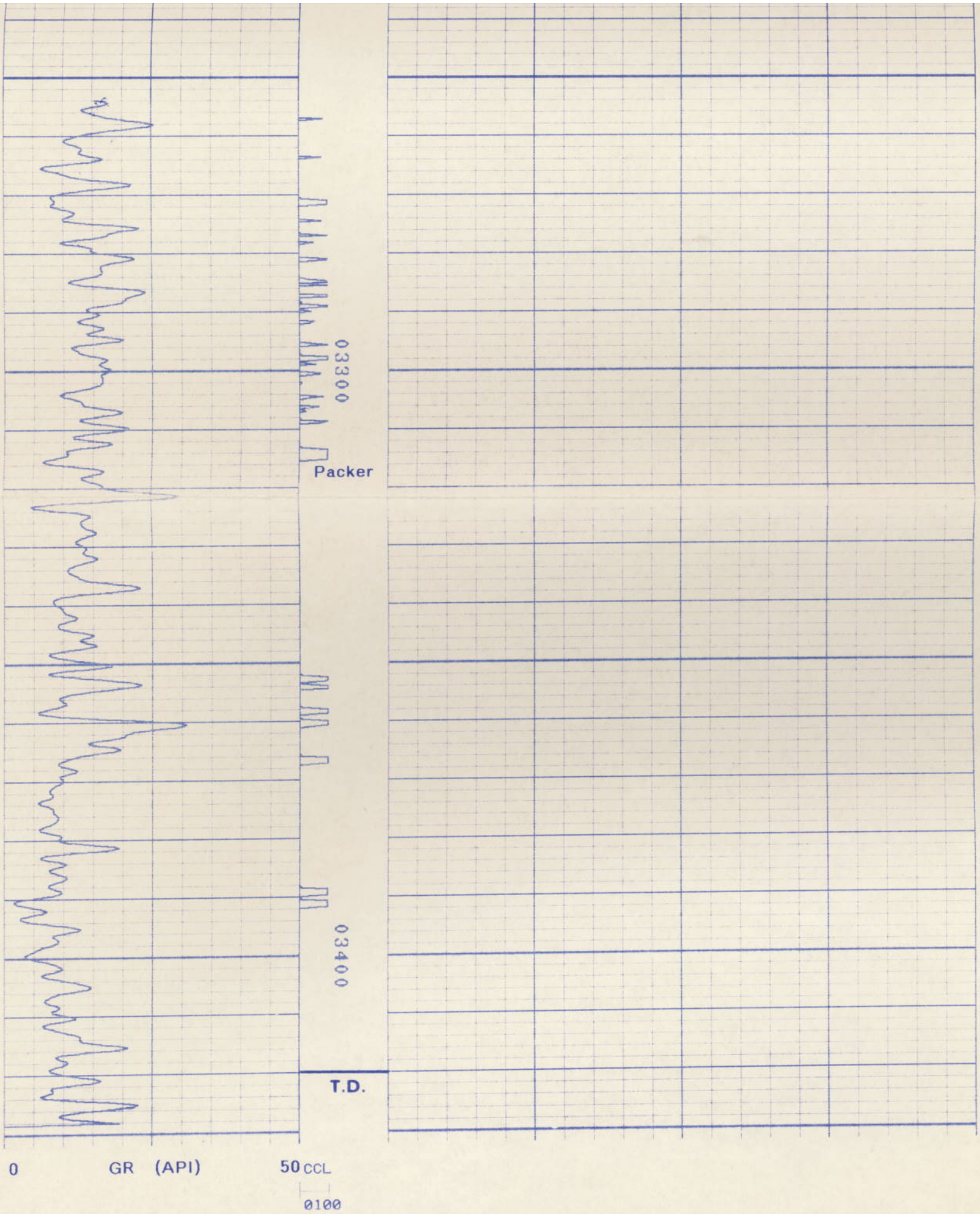
TRIP: 1

DATE: 03/08/96

TIME: 12:07:38

MODE: RECORD





****

FILE BELOW IS TIME DRIVE
STAT CHECKS PRIOR TO INJECTION
TIME IS 1245, SCALE IS 2 INCHES
PER 100. TIME MODE IS 1 SEC/FT.
****

****

FILE: 3

****

FILE: 3

Tool Positioned at 3350 ft.

stat. check run for 10 minutes, at same sensitivity as log.

*** NONE ***

PARAMETERS

*** NONE ***

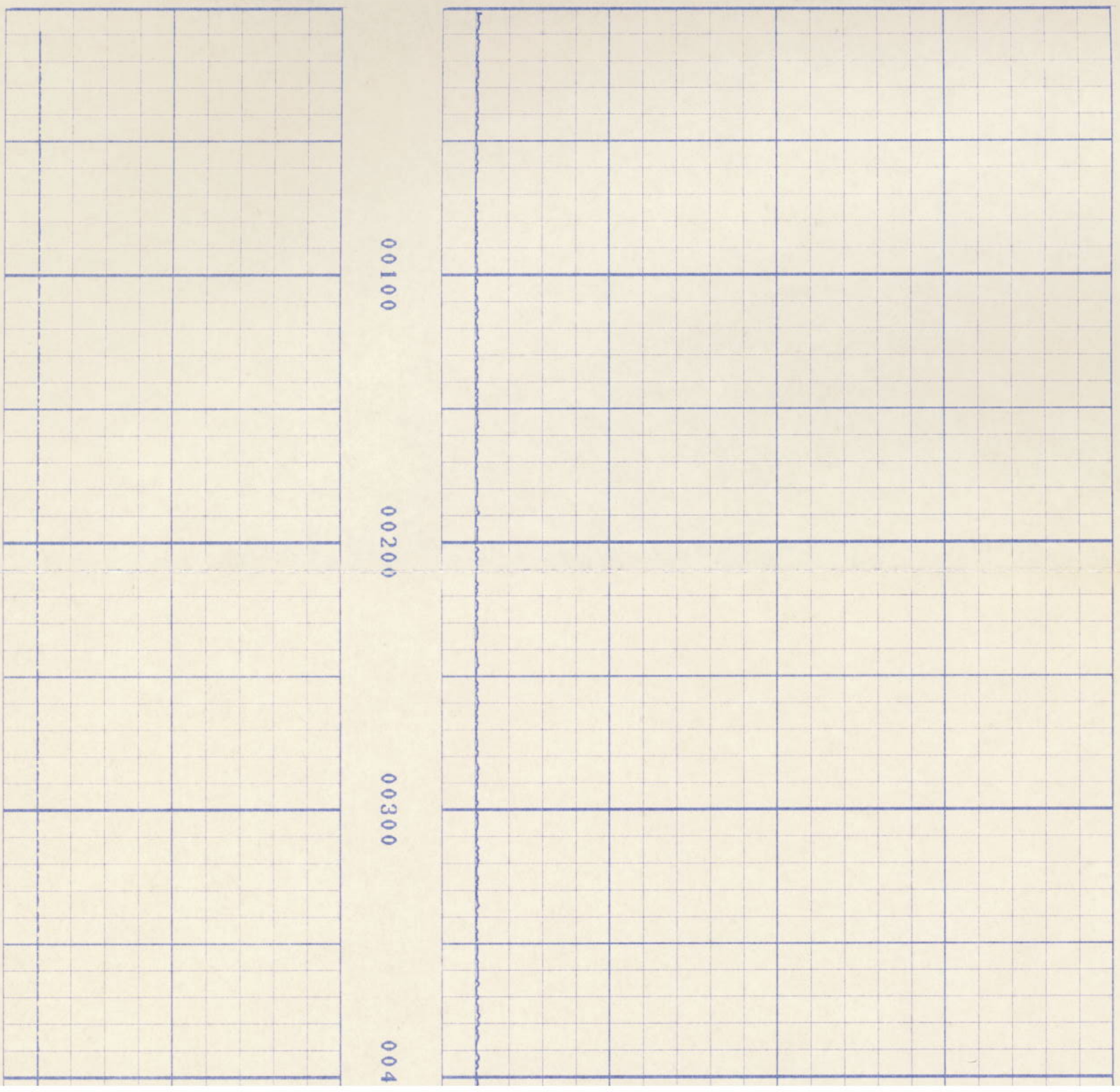
DISPLAY SCALE CHANGES

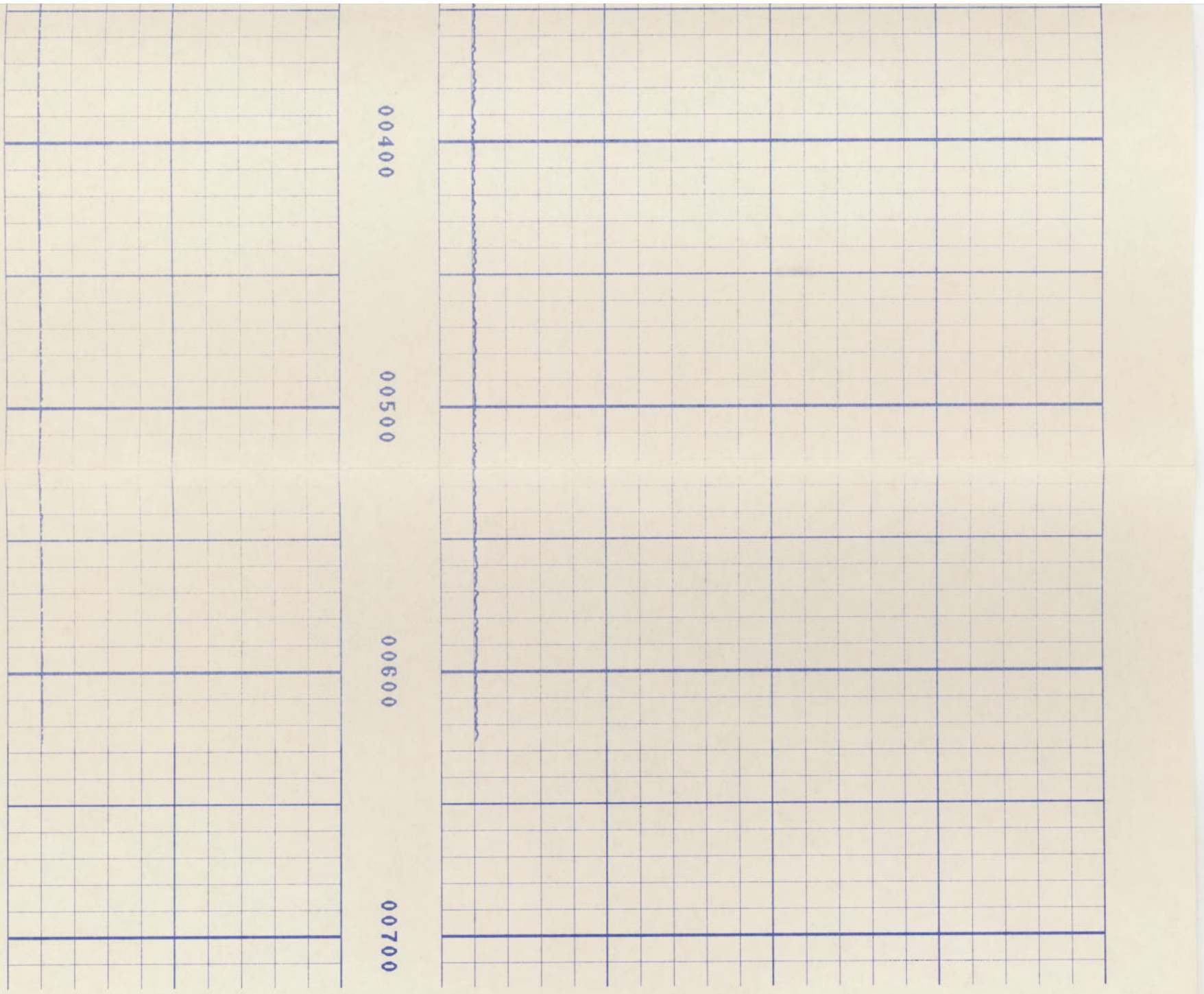
0100

CCL

0 400 0 400

TDET (CPS) BDET (CPS)





VELOCITY SHOT BELOW, TIME IS
1 PM. EXPECTED RATE IS 50 GPM.
****

****

FILE: 4

*** NONE ***

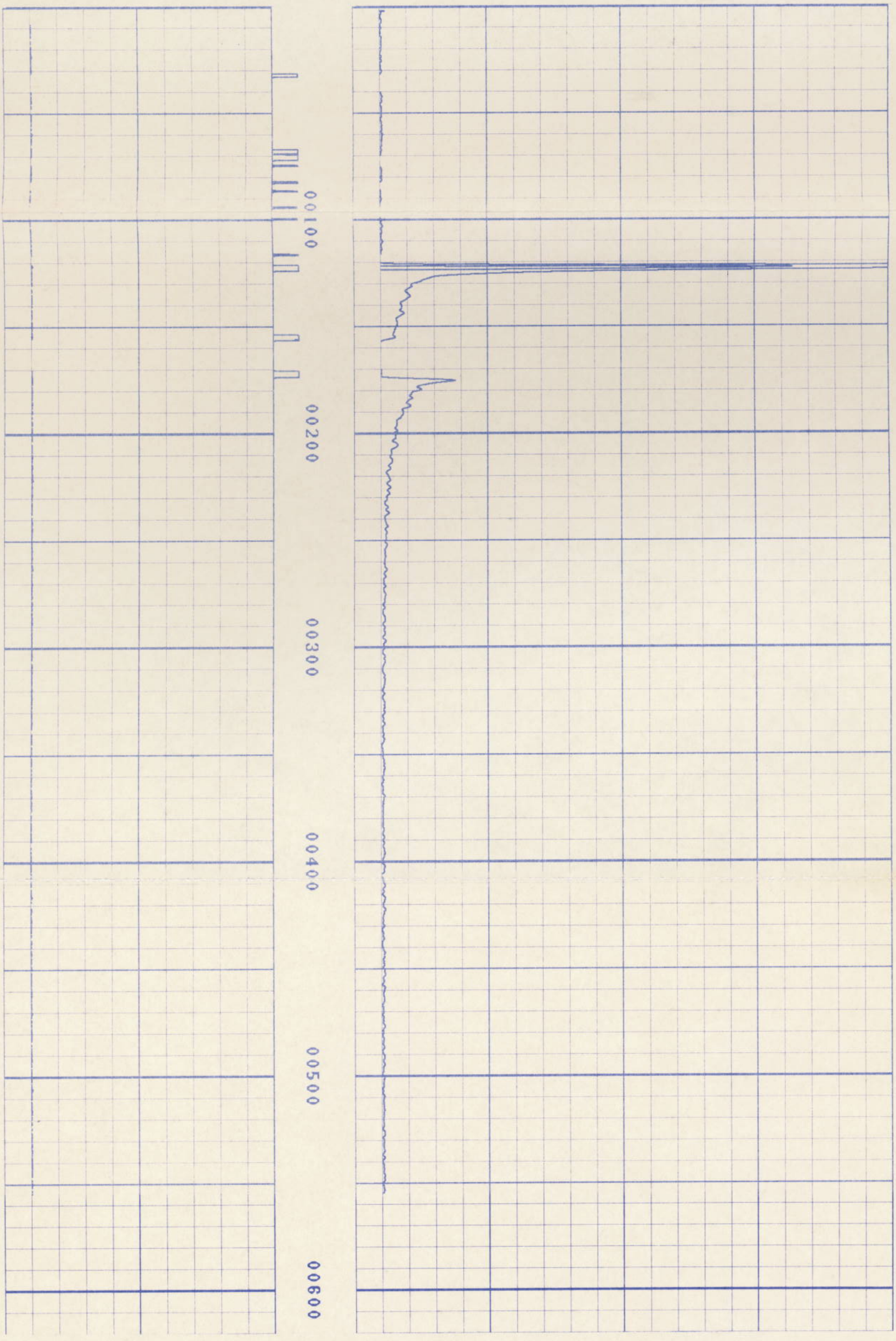
PARAMETERS

*** NONE ***

DISPLAY SCALE CHANGES

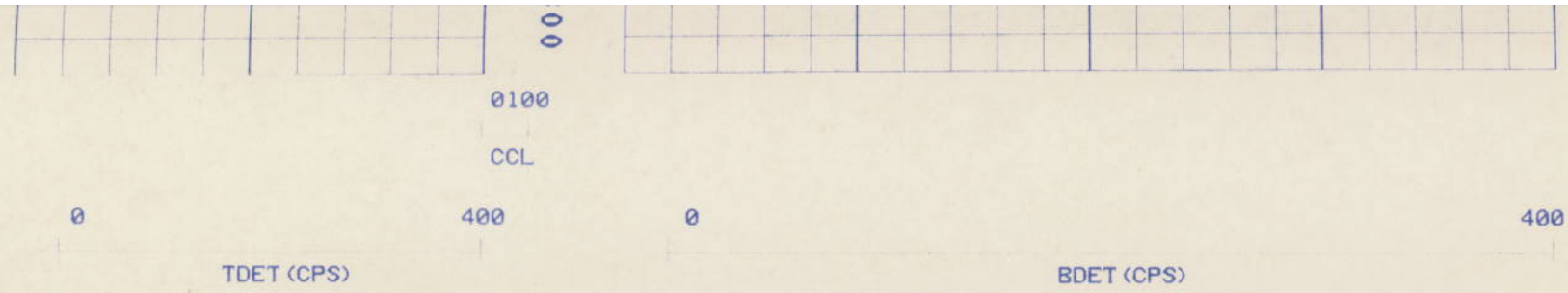
*** NONE ***

DISPLAY SCALE CHANGES



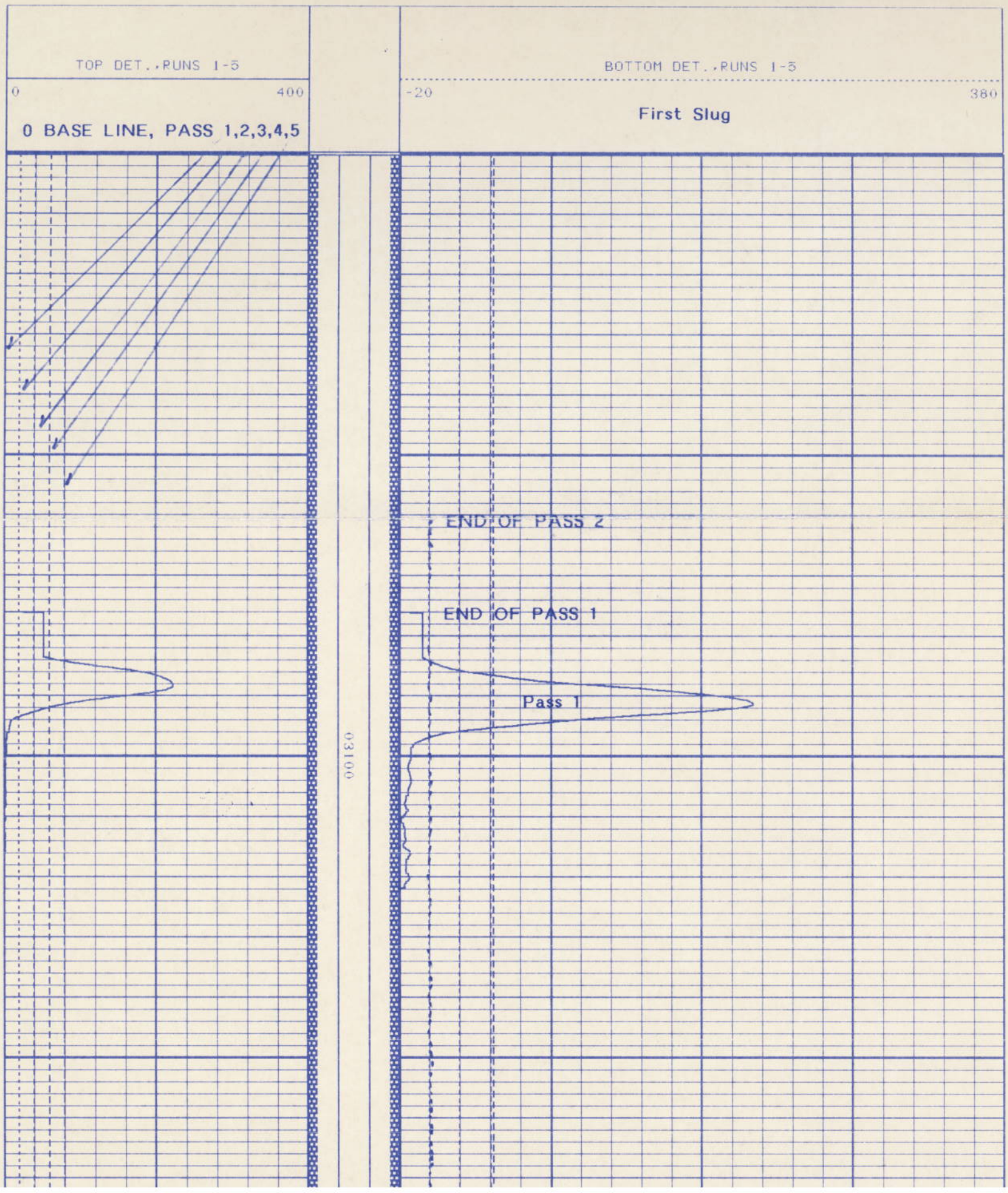
0100

CCL



TRACER SLUGS FIRED AT 3000 FT,
AND CHASED DOWNWARD.

Slugs Chased in Overlays Below; slugs fired at 3000ft.



END OF PASS 3

Pass 2

03200

END OF PASS 4

END OF PASS 5

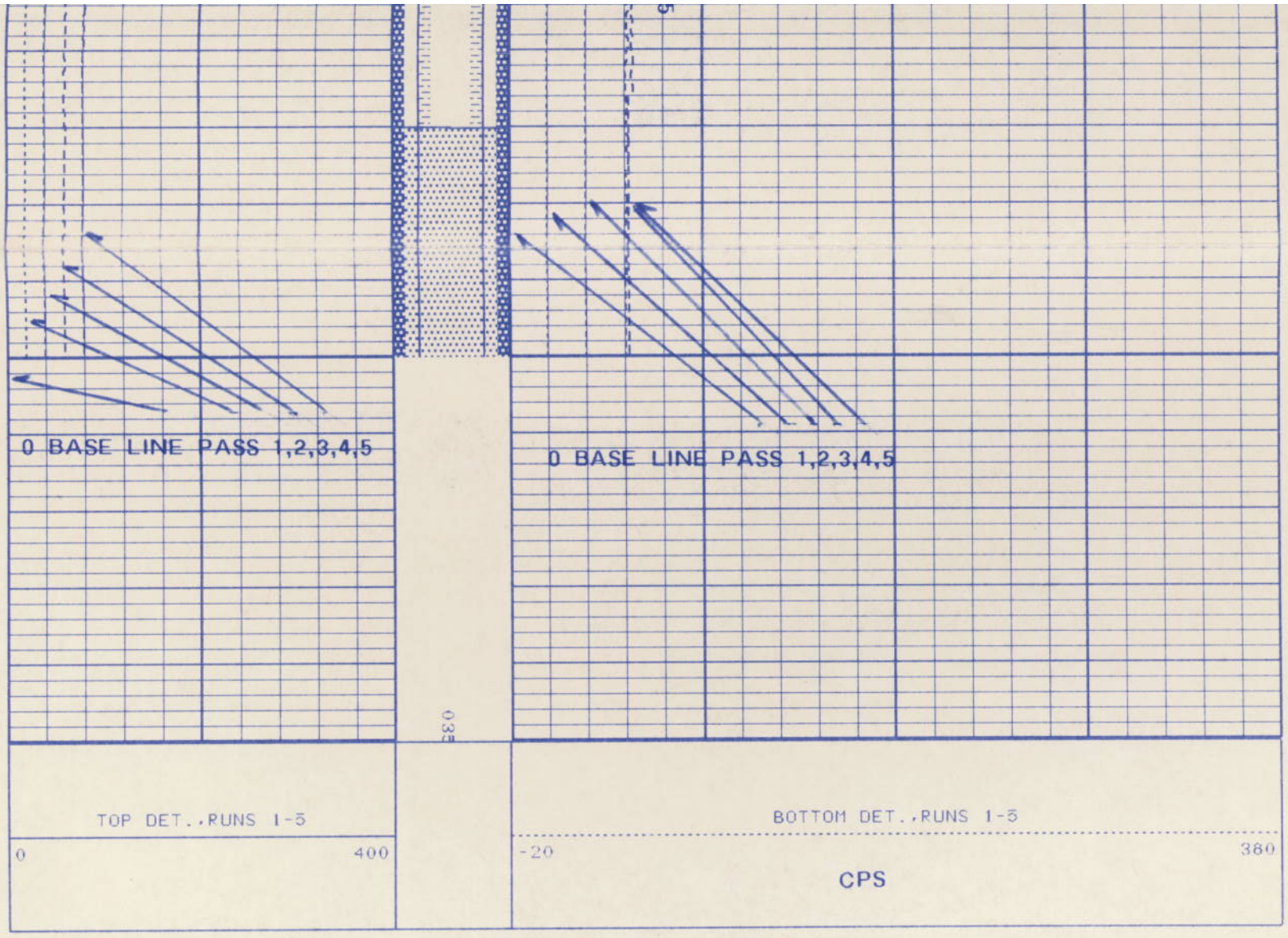
03300

Pass 3

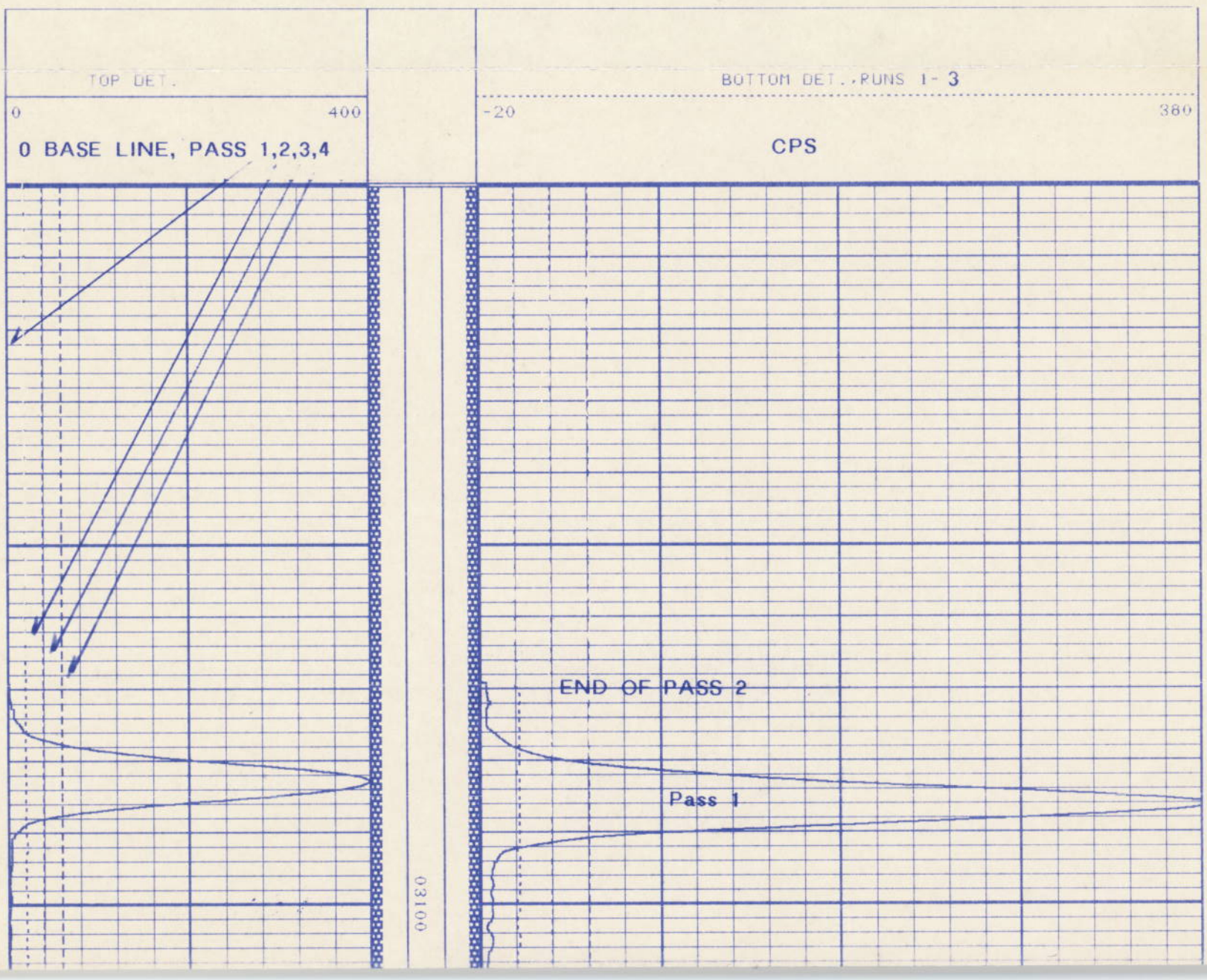
Pass 4

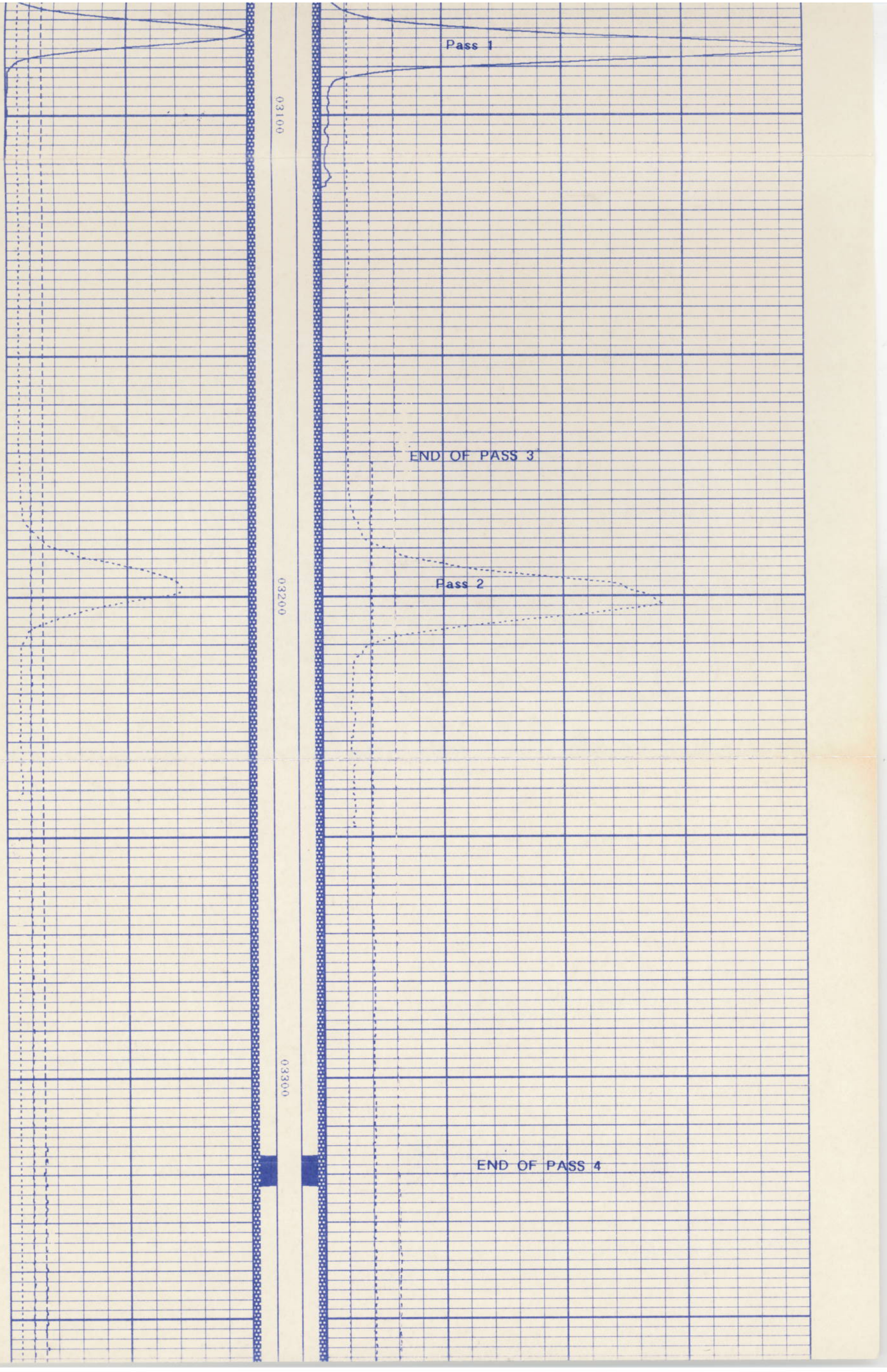
Pass 5

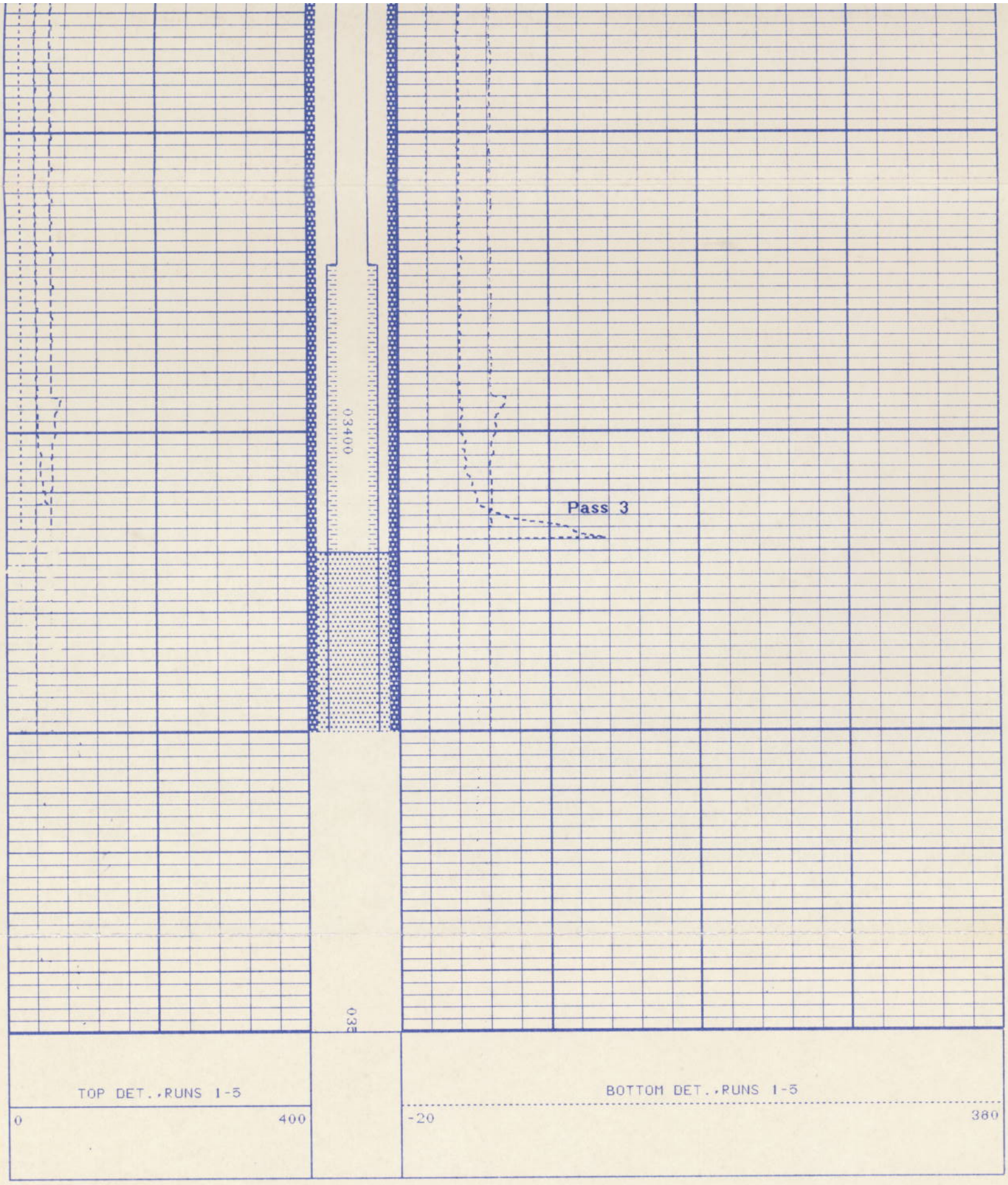
03400



Second Slug (Repeat)




03100
03200
03300
Pass 1
END OF PASS 3
Pass 2
END OF PASS 4



TIME DRIVE FILE BELOW, WITH
TOOL POSITIONED AT 3350.
TIME IS 2:30 PM. 3 SEC SLUG
FIRED, NO SIGN OF RETURN.
TIME MODE IS 1 SEC FT., LOG
RUN STATIONARY FOR 20 MINUTES.
****

CCL
0100

CCL

0100

TDET (CPS)

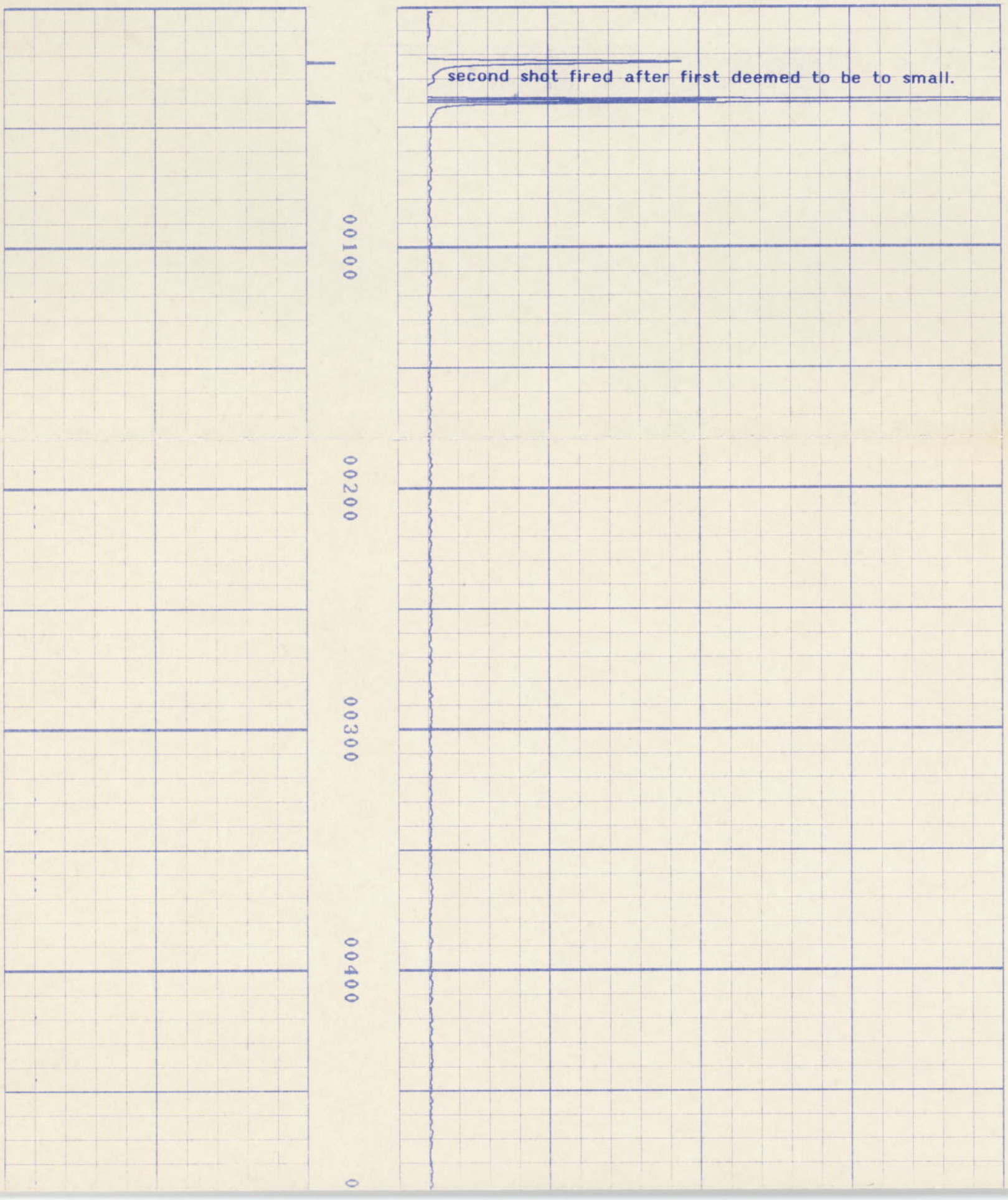
0 400

BDET (CPS)

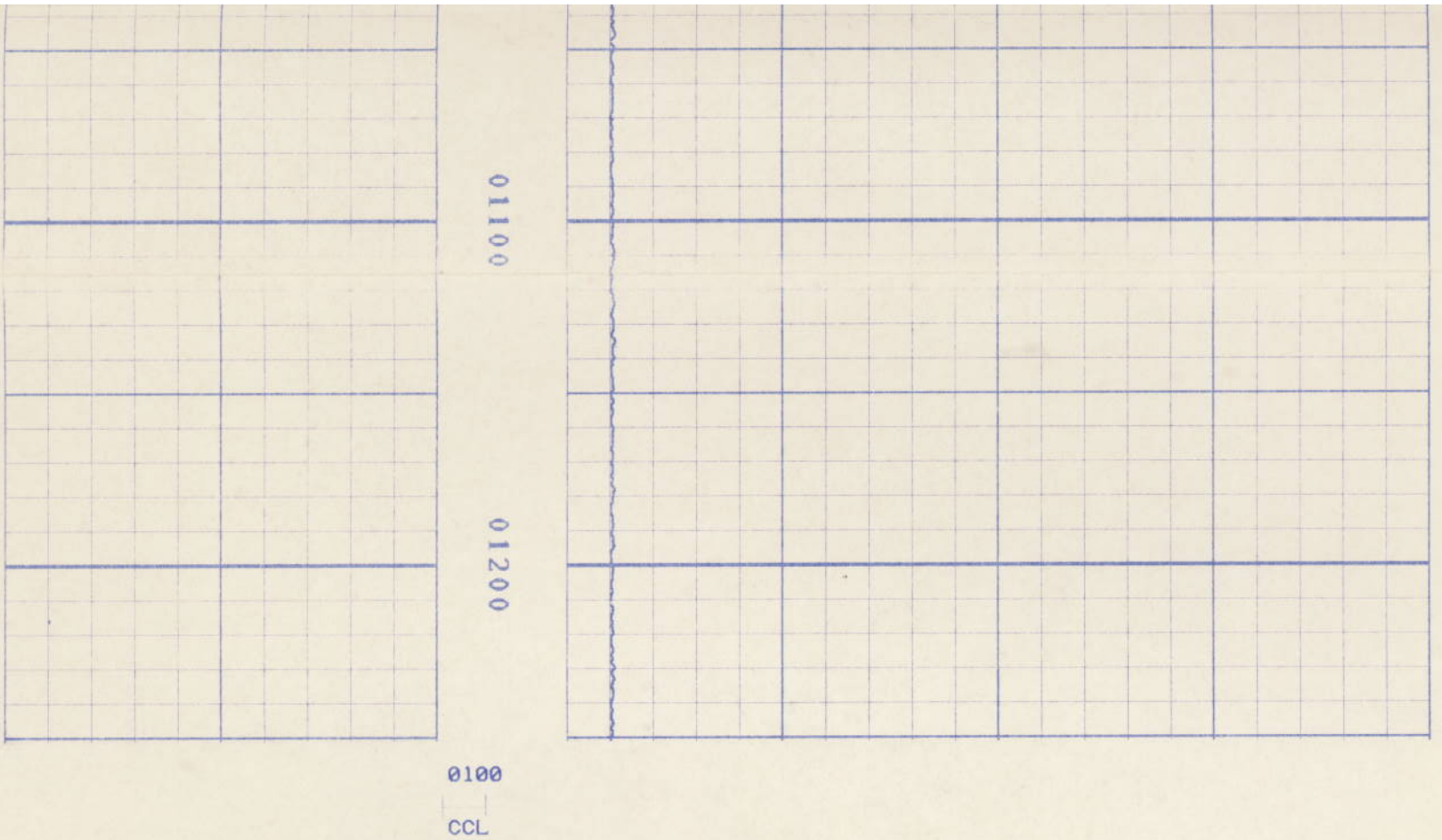
0 400

FILE: 1

****



00500 00600 00700 00800 00900 01000 01100



DEPTH: 3352

REVISION: FSYS256 REV:G002 VER:2.0 MODE: RECORD

SERVICE: M 150A FILE: 3 DATE: 03/08/96 TIME: 15:52:22

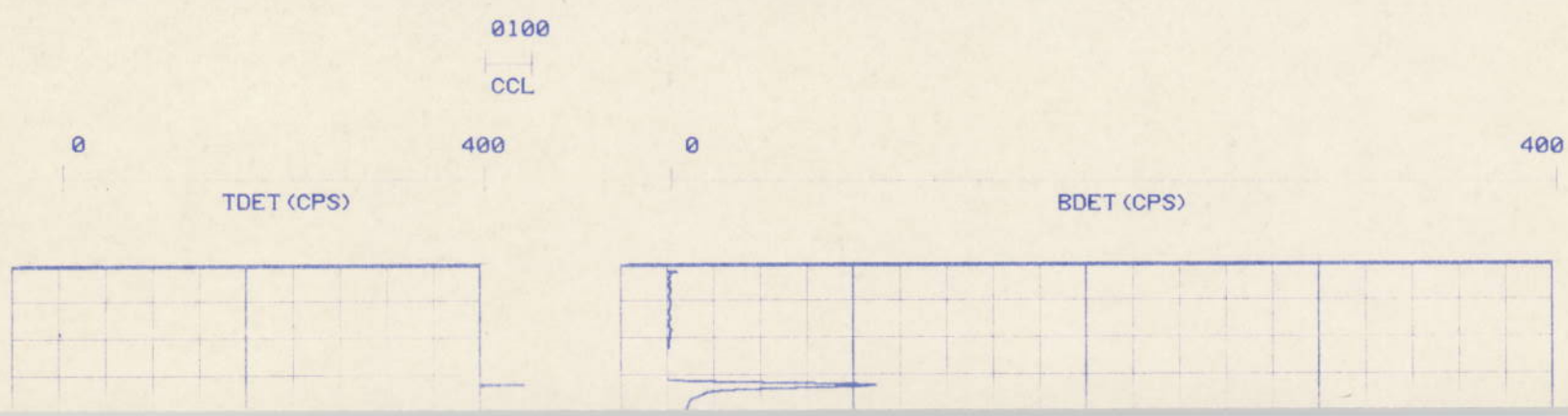
WELL NAME: WDW 49 TRIP: 1

COMPANY: HOECHST CELANESE RUN: 1

FILE: 3

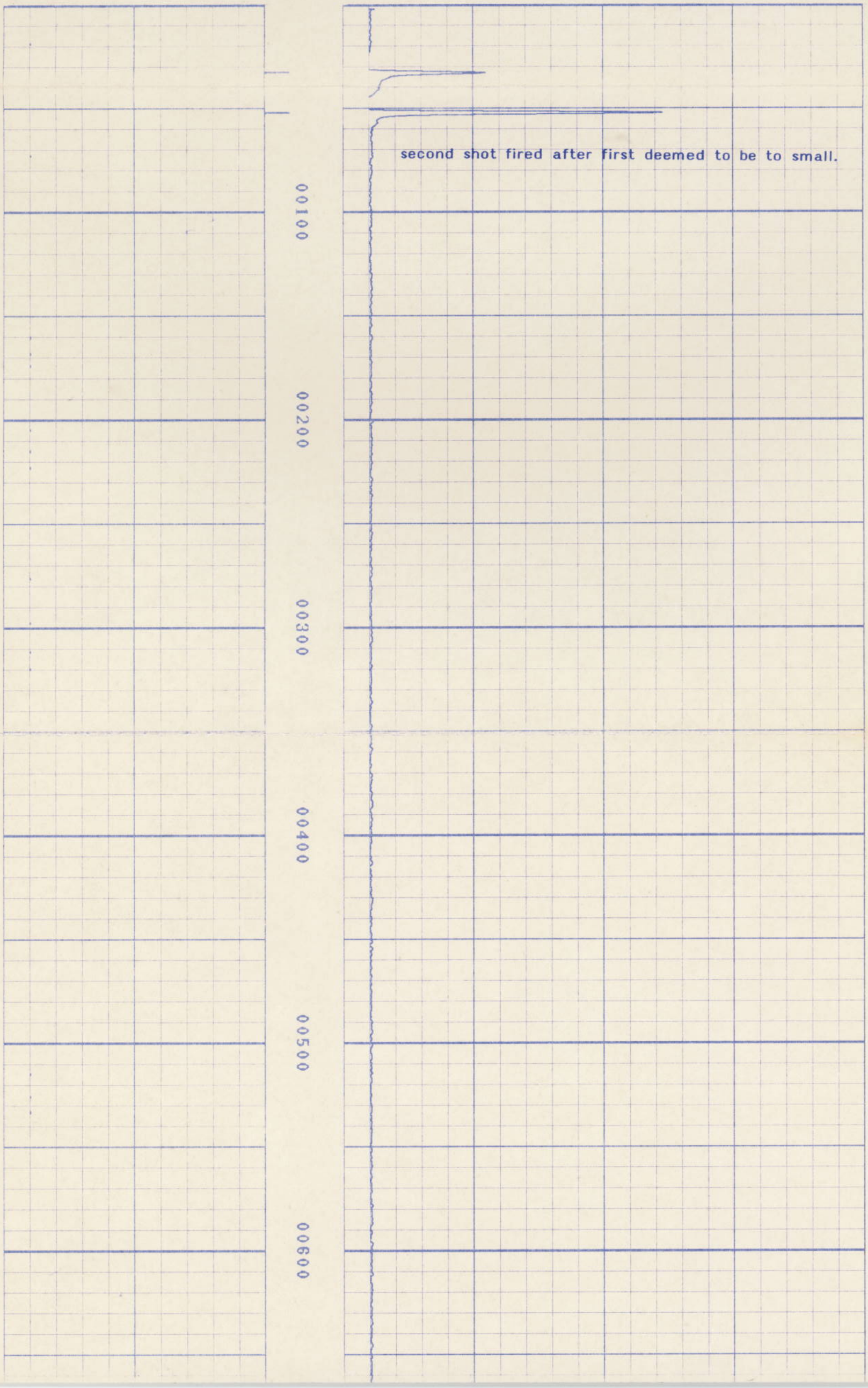
****

SECOND TIME FILE BELOW, TOOL STILL AT 3350. 3 SEC SLUG FIRED, RUN FOR 20 MIN.
NO SIGN OF CHANNEL.
BEGUN AT 352 PM
****
TIME IS 1 SEC/FT. FILE RUN FOR 1200 SEC, RATE IS STILL 50 GPM.



0 400 0 400

TDET (CPS) BDET (CPS)



FINAL BASE PASS BELOW

00600 00700 00800 00900 01000 01100 01200

FINAL BASE PASS BELOW.
AFTER INJ. RATE INCREASED
FROM 50 TO 190 GPM.
****
TIME IS 4:45PM

****

FILE: 5

CURVE DELAY REPORT

CURVE	PHYS. DELAY	UNITS
TDET	6,0	FT,IN
BDET	0	FT,IN
CCL	9,9	FT,IN

PARAMETERS

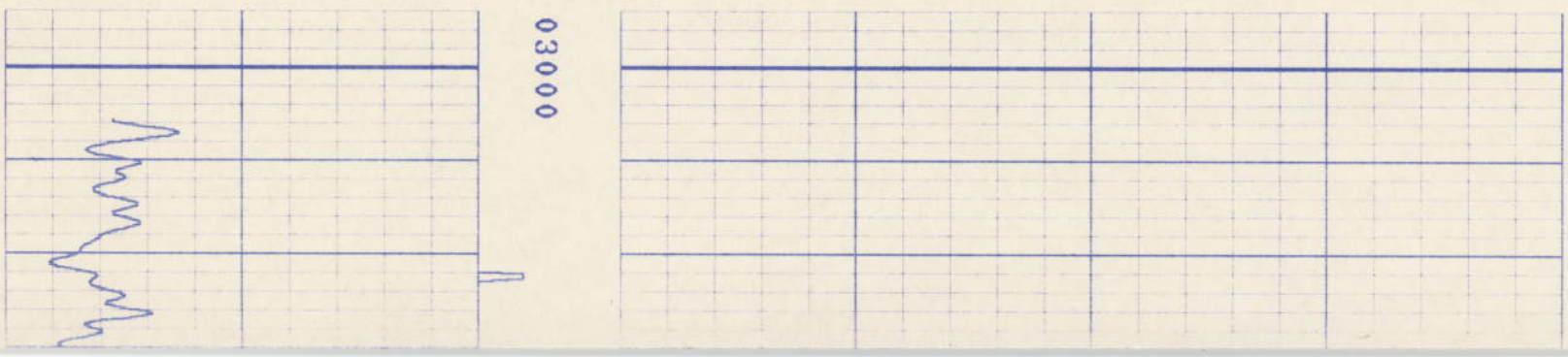
*** NONE ***

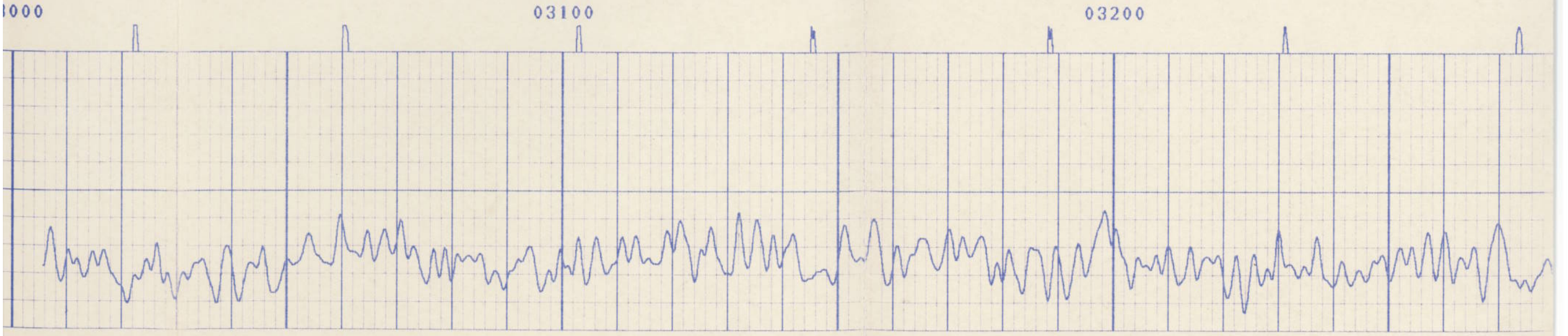
COMPANY: HOECHST CELANESE
WELL NAME: WDW 49
SERVICE: M 150A FILE: 5
REVISION: FSYS256 REV:G002 VER:2.0

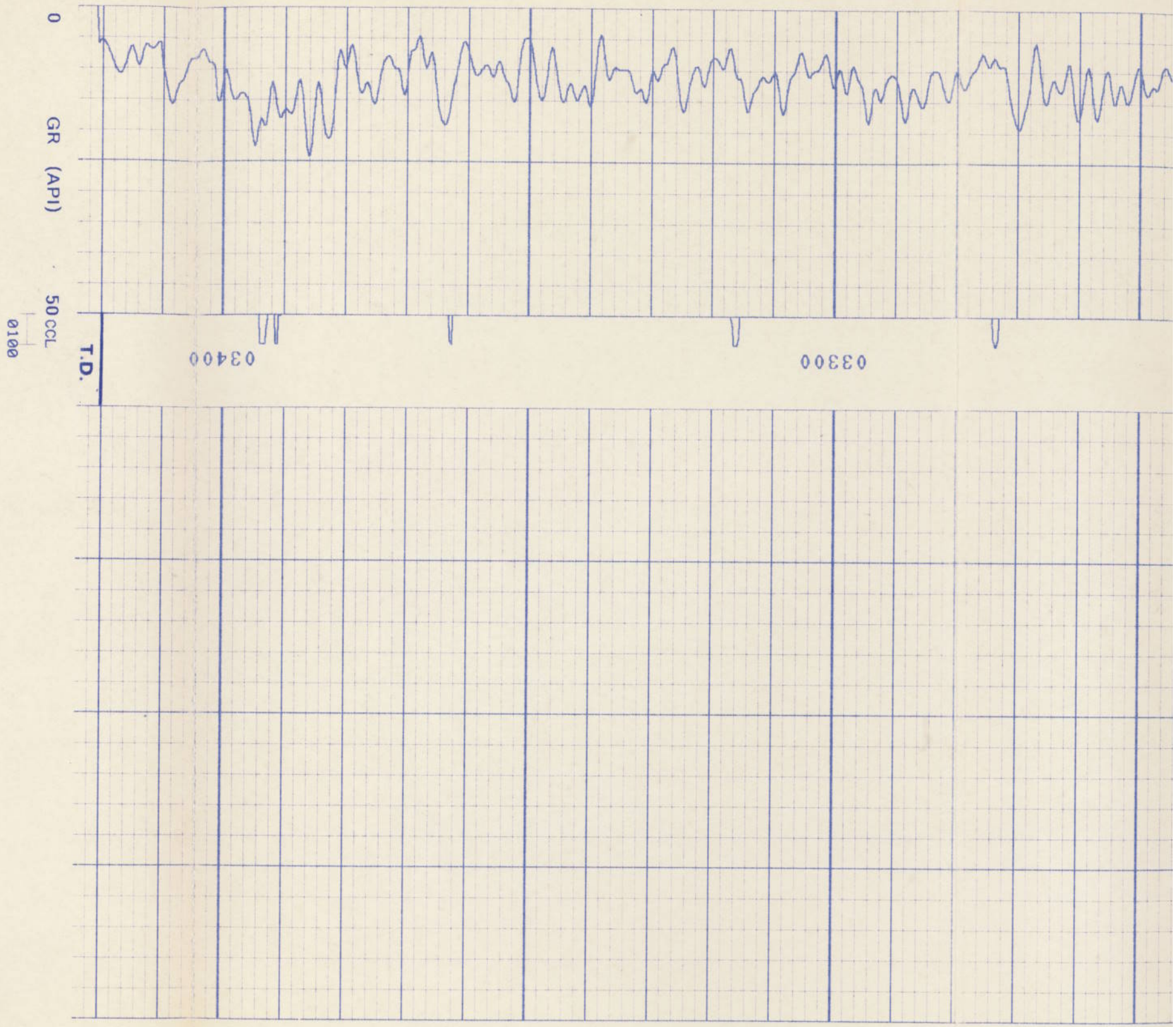
RUN: 1
TRIP: 1
DATE: 03/08/96
TIME: 16:40:07
MODE: RECORD

CCL
0100

0 GR (API) 50




3000
03100
03200


0
GR (API)
50
CCL
0100
T.D.
03400
03300